MODELLING FUNDAMENTAL FREQUENCY, AND ITS RELATIONSHIP
TO SYNTAX, SEMANTICS, AND PHONETICS

by

Douglas O'Shaughnessy

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Certified by

Thesis Supervisor

Accepted by

Chairman, Departmental Committee on Graduate Students
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ABSTRACT

The problem of modelling fundamental frequency (Fo) in English speech
has been approached experimentally by examining computer-generated plots
of Fo of spoken sentences recorded by several male speakers. These sentences
exhibit a wide range of syntactic, semantic, and phonetic phenomena, which
were specifically chosen to enable comparison of Fo contours and to locate
specific pattern alterations, which were then related to the linguistic
phenomena. In particular, Fo patterns have been associated with the convey-
ance of a message from speaker to listener. In varying his Fo, a speaker
encodes certain aspects of the linguistic message, to facilitate easier
perception on the listener's part.

Syntactically, Fo can be used to segment and delimit portions of utter-
ances into phrasal units, to mark sentences as yes/no questions, and to
mark the end of an utterance versus a pause in the utterance. Phrasal units
start with Fo rises and often end with Fo falls, but the ends of non-final
units frequently have small Fo rises, as opposed to sharper falls at the
end of an utterance. These effects were related to offset and deletion
syntactic transformations, and to distinguishing among ambiguous sentences.

Semantically, Fo can be used to highlight and emphasize those words in
each utterance that the speaker deems important to the message. Essentially,
the words least predictable from context receive the heaviest Fo marking or
'accent.' Certain 'inherently contrastive' word classes were found to have
heavier accent than others, and certain syntactic transformations had 'focus'
effects in that they shifted accent.
Phonetically, Fo was found to form a global pattern upon which accent rises and falls were superimposed. Accents were viewed as Fo obtrusions above a declining baseline. The sizes of these accents were related to the number present in each utterance, and to the proximity of accents to each other. The initial high Fo in an utterance varied with the length of that utterance. Speakers were found to have considerable freedom in varying Fo within the constraints of specific linguistic Fo patterns. There appeared to be a trade-off between minimizing effort by reducing the amount of Fo movement and increasing Fo movement to help convey information; the speaker economized by using as much Fo variation as required by the context of the utterance.

Language has been viewed as having three functions: conveying objective content, expressing the speaker's attitude toward the content, and relating the content of different sentences to one another. Other studies have partially analyzed Fo in the first language function, but this study examines Fo in all three. Taking a top-down view of Fo contours, an algorithm is presented to generate Fo-by-rule, based on the observations of actual speaker Fo.

THESIS SUPERVISOR: Jonathan Allen
TITLE: Professor of Electrical Engineering
This Thesis is dedicated to Mom and Dad.

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GLOSSARY OF TERMS AND ABBREVIATIONS:

In the text, tables, and figures, certain terminology and abbreviations are used that may not be familiar to many readers. To provide a quick reference, these items are listed below:

Fo - fundamental frequency
pk - peak Fo (highest Fo on the nucleus of a syllable)
dr - drop (decrease in Fo between syllabic nuclei)
jp - jump (increase in Fo between syllabic nuclei)
rs - rise (increase in Fo on a syllabic nucleus)
fl - fall (decrease in Fo on a syllabic nucleus)
ch - change (change in Fo: either a rise or a fall)
ds - descent (amount of fall accent = fall + drop from peak to the start of the next syllabic nucleus)
fo - fall-off (amount of descent + ensuing fall)
ac - accent, or rise accent (amount of Fo jump + rise, from the low Fo value on the last syllable to the peak on the accented syllable)
N - number of utterance-tokens
sp - speaker initials (JA, KS, ML, DK, DO)

Other abbreviations are: N - noun, V - verb, Adj - adjective, Adv - adverb, aux - auxiliary verb, mod - (class A) modal, art - article, prep - preposition, conj - conjunction, pron - pronoun, VP - verb phrase, NP - noun phrase, PP - prepositional phrase, AdvP - adverbial phrase, verbal - a verb, modal, or auxiliary; CR - continuation rise, PRPM - perceptually-relevant pitch movement, RF - rise+fall, FR - fall+rise, RFR - rise+fall+rise, SC - sub-contour, CI - center of intonation; Tune I or Tune A - statement Fo pattern, Tune B - yes/no question Fo pattern, Tune II - RFR pattern, P-unit - phonological unit; AS - accented syllable, US - unaccented syllable, IC - inherently-contrastive, MO - modality operator, CS - contrastive stress, PA - potentially-acceptable; CU - citation utterance, PU - paragraph utterance, Q/A - question-and-answer; FSP - Functional Sentence Perspective, CD - Communicative Dynamism, NSR - Nuclear
Stress Rule, VOT - voice-onset time, RP - Received Pronunciation.

msec - milliseconds, Hz - Hertz (cps), SD - standard deviation.

Bottom ordinary range, HLS - high level system, LLS - low level.

PI - prosodic indicator.

All unlabelled numbers refer to Fo in Hz. A positively-signed
refers to accent in Hz; unsigned numbers in the tables represent
values of Fo. 'Peak patterns' in the text of the form a-b-c-d.
a, b, c, ... are Fo peak values) represent successive peaks in
pattern on successive accented syllables. Accented syllables are
frequently underlined in the text. Reference to an Fo pattern
(a, b, c, ...) d (e, ...) represents abstracted data from the Fo
on 2 syllables, the first accented and the second not; 'a' and
sent drops or jumps to the start of the respective Fo patterns
syllabic nuclei, 'b', 'c', ... represent successive changes in
nucleus, and 'd' represents the Fo peak attained during the nuc
first and accented syllable.
1) **Introduction:**

1.1) **Fundamental Frequency in Speech**

Speech is the process by which most people communicate with each other, especially in short-term interactive situations. Other forms for the transferal of information exist, such as print media and various forms of coding, but speech remains the simplest and fastest way to convey a message from one person to another or to a group of people, and, unlike writing systems, speech is universal in human cultures. The question naturally arises as to how speech is used by people to convey ideas.

The speech waveform can be regarded as a sequence of segments, called 'phones,' in which adjacent segments differ from each other in at least one phonetic feature (e.g., location of formants, presence of voicing). Phones are acoustical realizations of phonemes, which are abstract linguist entities representing the individual sounds which constitute spoken words. The spoken word contains a number of phones in sequence, and the combination of a number of words in order can be used to produce a sentential 'utterance,' which is a basic unit of communication.

Automatic speech synthesizers have been implemented on computers to simulate the action and/or speech output of the vocal tract, when given a string of phonemes which would yield a word or sentence if spoken by a human. Conversely, automatic speech recognition by computer has been attempted by using phoneme-waveform relationships to abstract relevant information from the speech signal and convert the data into a phoneme string, when given a spoken utterance as input. Neither of these two attempts to
approximate speech by computer has been totally successful, primarily be-cause our knowledge and understanding of speech is limited. Many aspects of the relationships between the message and the speech signal are not well comprehended. One of the areas in which more research is needed is the realm of 'suprasegmentals.'

In speech there are many acoustic cues produced by the speaker to aid the listener in understanding the sentences being spoken. Certain acoustic cues are specific to the recognition of individual phonemes, whereas others can be defined more globally and depend on more than just the sound currently being produced. Some of the aspects of speech which range over more than one sound are called suprasegmentals; they are acoustically cued by the rate of vibration of the vocal cords (called fundamental frequency, or 'Fo'), by the durations of phones and pauses, and by the intensity of the sounds.

Suprasegmental features are perceptual aspects of the speech signal which exhibit themselves over a number of segments, and are independent of the segmental features. The aspects of speech referred to as stress, intonation, and juncture are generally regarded as the suprasegmentals (or 'prosodics'). While given phones have certain durations and intensities (and Fo values, if voiced), it is the relationship of these acoustic features across several phones that conveys the suprasegmentals.

These suprasegmental aspects of speech differ from the segmental features in that the former are not phonemic in English, i.e., their alteration will
not usually affect the identity of the words in the utterance, although the syntactic use to which a word is put is sometimes cued by suprasegmentals (e.g., to distinguish whether a word such as "export" functions as a noun or a verb). For the most part, they serve communicative purposes in acoustically conveying to the listener certain information that is often not represented in orthographic form. Merely by listening to an utterance, one can often discriminate the approximate sex, age, health, mood, and attitude of the speaker, independently of what he is saying (the phonemic content). The suprasegmentals perform a major role in this information transferal since they have only a minor role in phonemics, and are able to utilize their presence to convey other facets of the signal. Besides the personal characteristics of the speaker, other useful information is transmitted via the suprasegmentals. Speech in which the suprasegmentals carried no information would be analogous to reading the phonetic transcription of a sentence in which punctuation marks, spaces between words, and stress markers had been removed. For most sentences, all of the needed information would be there, but it certainly would be simpler if the delimiters and other marks were left in, and indeed certain sentences must use non-phonemic information to discriminate meaning. Virtually all sentences can assume different 'meanings' (often subtle), depending upon how the speaker pronounces it. This is an advantage the spoken sentence has over the written version; to convey a special meaning of a sentence, the writer is limited to tools such as italics and other punctuation marks, which are frequently insufficient; whereas the speaker can utilize his suprasegmentals to present a wide range of meanings, depending (among other things) upon where he places stress in the utterance. The speaker can express fear, anger, sarcasm, etc., which are
generally beyond the range of the written sentence.

Even when the sentence does not have special meanings and the speaker is not expressing emotion, the suprasegmentals provide useful functions in speech: those of syntactical and semantical marking. Unlike the written sentence, which shows spaces between the words and uses punctuation to perform a syntactic function, in fluent speech there are no pauses between most words, and without some suprasegmental inflection speech would sound like a long string of phones, with no inherent way of dividing them up into words or phrases. Furthermore, the locations of lexical stress in polysyllabic words (indicated by stress marks in a phonetic transcriptions) are utilized in speech and help convey meaning. While words generally do not have pauses between them, the speaker can insert pauses at crucial points where a syntactic ambiguity might result, and also at certain phrase boundaries.

The suprasegmentals of speech are usually grouped into at most 5 categories: intonation, rhythm, loudness, stress, and voice quality (Lehiste, 1970; Fry, 1968). The first 4 are important for conveying linguistic meaning in English, whereas voice quality, while useful for signalling the speaker's emotion, apparently does not assist much linguistically in English. The remaining 4 subjective (i.e., perceived) prosodic categories are represented in the acoustic signal primarily by fundamental frequency, durations, and intensity.
Since not all phones are voiced, quasi-periodic glottal pulses are not always present in the speech signal. But since every syllable contains a vocalic nucleus (usually including a vowel), a sequence of non-zero Fo values is produced on each syllable of speech. While voicing can be used as a phonemic feature in English (Haggard et al, 1970), the speaker is still relatively free to utilize the excursions of his Fo to signal non-phonemic phenomena in English. Other languages, known as tone languages, do not have as much freedom as English, because they utilize Fo extensively for phonemic purposes in vowel and word identification (Fromkin, 1972).

This thesis confines its attention to Fo, among the suprasegmental correlates. Previous studies have ranked Fo above duration and intensity in order of importance for stress and intonation purposes (Fry, 1955; 1958). A relatively high Fo carries more 'weight' in a linguistic sense than a long duration or a high amplitude, for example. It should be emphasized here that measures of the suprasegmental correlates are all relative (for example, by itself, a syllable with an Fo of 150 Hz signals nothing with regard to stress; but if the surrounding syllables have Fo's of 130 Hz or less, then the syllable with the higher Fo will likely be judged stressed). To determine the effect of suprasegmentals, one must consider the environment, how they relate to their context.

This thesis is a study of Fo in English speech: how to model it and describe its behavior as a function of linguistic and phonetic variables. The objective is to gain a better understanding as to what information a speaker
is conveying to a listener by his manipulation of Fo in speech, and as to how such information is encoded into Fo. One application of this research is to build a model for Fo which will accept linguistic information as input and yield an acceptable set of Fo values as output. Such a model would be useful in speech synthesis-by-rule applications, in teaching English language learners and deaf people, and in gaining a better understanding of the speech process in general.

1.2) Functional Load of Fo

The study of Fo has been hampered by its multiple role in English speech. Wang explains that an Fo pattern "is the result of two complex sets of factors: (1) instructions that realize certain types of linguistic formatives contained in the surface phrase-marker of the utterance, and (2) operating characteristics (...OC) of the speech mechanism" (1972:487). "The set of linguistic instructions carries cognitive content," and "the formatives which determine these instructions are discrete and are usually organized hierarchically," whereas "the OC ... are largely independent of the language," but "may vary from individual to individual;" they are "less determinate and more subject to free variation than the linguistic instructions" (487).

Unlike aspects of segmental acoustics which can be isolated and related to specific functions as conveying to the listener a specific phoneme, Fo serves several functions in the speech message. Fo functions phonemically in helping to distinguish syllable-initial voiced and unvoiced consonants (Haggard et al, 1970; Lehiste & Peterson, 1961:420). Fo operates lexically
in conjunction with duration and intensity to distinguish between two words with the same phonemic composition; such noun-verb pairs as *import-import* (with the lexically-stressed syllable underlined) are distinguished via a manipulation of these three acoustic factors, with *Fo* being the primary impetus (Fry, 1968:403-4).

*Fo* assists in a **syntactic** and grammatical manner, so as to delimit and segment an utterance hierarchically into smaller units, and to integrate syntactically cohesive phrases together, for easier processing by the listener (Daneš, 1960:44). This syntactic function is one of the two phonological roles that *Fo* plays, of major interest in this thesis. The other is the **semantic** function of *Fo*, in which *Fo* acts to highlight and call to the listener's attention the more important words in an utterance. It is in this function that *Fo* performs its stress and emphasis duties, and assists in identifying 'new' and 'old' information in an utterance (Daneš, 1960:45-6; Sgall et al, 1973). (One possible difference between syntax and semantics in *Fo* usage has been postulated by Adams (for Australian English): "the syntactic function of intonation is indicated largely by the direction of the pitch movement and its expressive function by the degree of this movement" (1969:104). While this is an oversimplification, the results of this thesis support this statement.)

*Fo* also helps to convey the current emotional state of the speaker and his **attitude** toward the utterance (Lieberman, 1961; Lieberman & Michaels, 1962; Williams & Stevens, 1972). And finally *Fo* functions also to convey
such personal information as to allow the listener to distinguish (approximately) a speaker's age, sex, and general health (Collier, 1972:161), as well as helping "to identify the individual speaker," his "linguistic background," and "emotional state" (Lieberman, 1970:180; also Atkinson, 1973:26).

In addition to these multiple functions, certain aspects of the Fo contour in an utterance can be attributed to phonetic factors which can be related primarily to anatomical and physiological constraints on vocal cord and vocal tract operation. These phonetic Fo effects appear to have little direct linguistic function in speech, although they may well be related to information in the non-phonological functions (e.g., emotion; speaker characteristics). These Fo phenomena cannot be ignored, since it is likely their absence or misapplication in synthetic speech that leads to part of the 'unnaturalness' of such speech.

1.3) Linguistic Communication

1.3.1) Language Functions

Prior to observing how Fo can be used to convey linguistic information in the utterance of a text, one must analyze certain aspects of sentences and discourse, viz., those functional aspects related to how a text is organized so as to efficiently convey a message to the listener. Assuming that the speaker's objective is to transfer a message to one or more listeners, he must arrange his words according to a set of syntactic rules following the convention of the language (English), but he has a considerable amount of freedom in choosing among the many syntactic options for the order of the
lexical items he wishes to utter, and in framing those items in a structure designed to convey the intended message. Specifically, the speaker chooses that word order and those structures which give proper emphasis to certain words and segment the utterance into small enough units for easy processing by the listener.

Halliday views language as having three main functions (1970a:143):

1) the expression of content, called the ideational function. This aspect of language is used to convey the propositional or 'objective' content of an utterance, which consists mainly of nouns and verbs.

2) the establishment of social relations, called interpersonal role of language. This aspect involves the speaker's attitude toward the content of the sentence, "the relations among the participants in a speech situation, and the speech roles assigned by the speaker to himself and his interlocutors" (1969:81).

3) the forging of links with itself and the context, called the textual function. This last aspect "concerns the structuring of the act of communication within the total framework of a discourse, the delimitation of message units and the distribution of information within them" (81). "The construction of discourse demands resources not only for attaching a sentence to what has preceded it but also for organizing the sentence in such a way that it is appropriate as information in the context" (1968:210).

The ideational function of language is represented in each sentence by the proposition or 'nucleus' portion, which involves the basic notions of
subject, predicate, and object/complement. The proposition normally contains the 'function' words and such 'content' words as nouns, verbs, and adjectives. This distinction between content and function words is discussed further in 5.1.1, but basically it distinguishes 'closed' class function words, which primarily serve grammatical purposes in the sentence, from the 'open' class content words, which provide the main information content of each sentence. The proposition of a sentence can be viewed as its basic foundation, i.e., those elements that the sentence must have to be grammatical and convey a message to the listener or reader. In contrast, the items of a sentence related to the interpersonal function of language can be viewed as elements additional to the proposition, 'optional' in the sense that they are not required for the sentence to be grammatical. They include such content words as sentence adverbs, negatives, certain modal auxiliaries, and quantifiers (collectively denoted 'modality operators'); these words delimit and modify the message presented in the proposition (Fig. 1).

1.3.2 Functional Sentence Perspective

To explain the word order of sentences in discourse, the Prague school of linguists has proposed a theory called "Functional Sentence Perspective" (FSP) in which the sentence is analyzed into its 'functional' elements (Firbas, 1964, 1966, 1968, 1969; Sgall, 1967, 1969). The sentence is viewed as consisting of 3 sections: theme, transition, and rheme. The rheme is that part of the sentence containing the greatest amount of 'new information' for the listener, while the theme has the least, and the transition lies in between. This concept of 'amount of new information' (also called degree of
"Communicative Dynamism" (CD), or "the extent to which the sentence element contributes to the development of the communication" (Firbas, 1968:38)) is the key to the theory and is related to the word order of a sentence and to the degrees of emphasis individual words receive. The normal (or basic) distribution of CD in a sentence is to "arrange the sentence elements in a consistent theme-transition-rheme sequence" with "the degree of CD starting with the lowest and gradually passing on to the highest" (1966:115).

Besides word order, FSP (defined as "the distribution of various degrees of CD over the elements within the sentence" (1968:38)) is determined by the context of the utterance and the semantic structure of the particular language. Context (i.e., the sentences which precede a given sentence in a discourse, plus background knowledge common to the speaker and listener) is particularly important for English FSP, because in English (rather than, say, Czech or German) there are more syntactic restrictions upon the word order a sentence can take; e.g., low CD words may be restricted to occur at the end of a sentence in some cases. Thus it should only be taken as a tendency for the theme (which includes all previously known words) to occur early in a given sentence, and the rheme (which is a subset of the 'new' information) to occur late (1966:255), "in accordance both with the linear character of human thought and with the linear character of the sentence" (1964:115).

A heuristic way to view FSP concerns that of topic and comment, where the first part of each sentence is considered as a topic, about which the rest of the sentence makes a comment. Thus it is natural for the speaker to place
old information in the topic, so as to set the stage for new information in
the comment. By placing the old information (which contributes "compara-
tively little to the development of the communication" (Firbas, 1968:12))
first, the speaker provides the listener a specific context in which to
evaluate the new, unpredictable information. Viewed alternatively as a
communication-in-noise problem (which speech represents), it is more
efficient to place old information first and then the new information, so as
to reduce the number of possible lexical items that may occur at any given
point. That is, the listener, at the start of an utterance expects to an-
ticipate hearing an item previously mentioned in the discourse, and after the
first few words, he alters his expectations according to those early words.
As Firbas puts it: "it is most natural for a discourse to be developed
gradually," and "for a speaker 'to begin at the beginning' and gradually
proceed towards the fulfillment of the communicative purpose of the dis-
course" (1968:39).

Halliday's textual aspect is built on the ideas of FSP (1970a:161). He
agrees with the concept of a basic distribution of CD, saying that the first
part of the sentence "will be associated with the 'given'"., and the latter
part "with the 'new' unless there is good reason for choosing some other
alignment" (162). "By the 'given' we understand that part of the message
which is shown, in English by the intonation, to constitute a link in the
chain of discourse," with the 'new' being "nonrecoverable information. This
is either additional to or contrastive with what the hearer is being presumed
to have available to him." "The given . . . links the information unit to the
rest of the discourse. It is often explicitly anaphoric, cohering with the
preceeding text through . . . lexical repetition, . . . grammatical reference, substitution (including ellipsis), and conjunction" (1970b:354).

The means of realizing FSP in speech include intonation, word order, and grammatical means such as articles and pronouns as well as syntactic transformations (Sgall, 1967:205; 1969:74). Concerning intonation, there appears a direct relationship between stress and CD: "the thematic elements are un-stressed and the transitional elements are prosodically lighter than those carrying higher degrees of CD (which in their turn are prosodically heaviest)" (Firbas, 1968:21). Further, the "rheme is most naturally signaled by the nucleus," where "nucleus" refers "to the prosodic features of a fully stressed syllable which stands out from among its neighbors . . . in that it displays (at least through initiating it) a change in pitch direction" (1968: 41). Such Fo movement for the purpose of emphasis is denoted in this thesis as 'Fo accent;' accent on the lexically-stressed syllable of a word leads to that word's being perceived as 'stressed' by a listener. This tendency for new information words to receive Fo accent-marking is a major theme of this thesis. The 'interpersonal' function of language will be related to accent effects of the modality operators, and the 'textual' function will be associated with the accenting of 'new' words and de-accenting of 'old' words. Topic/comment distinctions are examined later in the Fo effects of offset transformations.

1.3.3) Syntactic Transformations

Concerning word order, Halliday states that, in the unmarked case, the initial section of a clause will contain "the subject in a declarative sen-
tence . . . Any clause in which the element so designated does not occur initially is said to [be] marked" (1967a:10). A sentence such as "These houses my father sold," in which the object has been selected "as a point of departure for the message, thus constitutes a special 'foregrounding" (11). The basic sentence word order of English (subject-verb-object/complement) can be altered by several syntactic transformations, some of which are described below and were used in the corpora of this thesis.

The basic ideas of a Transformational Grammar concern a generated, semantic 'deep structure' image for each sentence and a set of syntactic transform rules, some of which must be applied to the sentence (obligatory rules) and others which may be so applied (optional rules), with the result being a 'surface structure' sentence. These transformations can alter the word order of a sentence, and insert (or delete) function words in the sentence. They usually do not change the propositional or objective content (the basic nuclear idea of the sentence), but, just as a shift in accent in an utterance can subtly alter the interpretation of a sentence, transformations can change the meaning of a sentence, via altering its non-objective content.

"Transformations allow the presentation of linguistic material in a variety of positions and surface structure relations without affecting the underlying grammatical relations, i.e., the way the sentence is understood." Their functions are "to organize and make retrievable the underlying grammatical relations; and to display emphasis, topic, and comment" (Smith, 1971: 228). Among the purposes of transformations are such functions as "indicating focus, emphasis, contrast . . .," and especially altering "the basic
theme-rheme progression of a sentence" (Hinds, 1975:97-98). Further, "all grammatical devices used in a single sentence must be compatible in terms of their functions (i.e., purposes), or the sentence will tend to become bad" (92), where by "bad" is meant "not completely natural in a neutral context" (84); thus 2 different transformations should not be "used to achieve cross-purposes" (94). In this thesis, the concentration is entirely on optional transformations, i.e., transformations which may be exercised by the speaker, to accomplish a specific linguistic objective. The purposes or functions of the transformations will be related to the Fo patterns that result in utterances altered by syntactic transformations.

1.4) Organization of the Thesis

Chapter 2 presents a background framework against which to evaluate the Fo analyses of later chapters. It reviews the relationships of Fo to pitch, intonation, and stress, and suggests which Fo movements are the most likely ones used by the speaker to convey linguistic information to the listener. Those movements most readily controlled by the speaker and perceived by the listener are the best candidates.

Chapter 3 describes the methodology of the experiments and the forms of the figures and tables, as well as the range of linguistic phenomena explored. Chapter 4 summarizes the Fo phenomena discovered, under headings of syntax, semantics, and phonetics. A hierarchical view of the Fo contour is presented, the units chosen for Fo analysis are reviewed, and a statistical analysis of one very controlled set of sentences is given.
Chapter 5 covers the semantic or emphasis Fo phenomena in detail. The effects are divided into lexical, contextual, and transformational categories. The lexical effects concern inherent accent probabilities of different classes of words, while the contextual effects relate accent variations to the interaction of words in sentences and discourse, and the transformational phenomena involve Fo variations due to the various arrangements of words in a sentence. Chapter 6 views the syntactic and delimiting Fo effects in detail. Terminal Fo patterns are explored, as well as how Fo is used to segment an utterance. Continuation rises are discussed, and the Fo effects of offset and deletion transformations are examined.

Chapter 7 analyzes the inherent phonetic relationships in Fo phenomena. Global patterns such as the Fo carrier, and local effects such as anticipation, separation, and consonant voicing are discussed. Sources of intra- and inter-speaker variation in Fo are analyzed, and Fo patterns are related to an economy principle.

Chapter 8 gives an algorithm to generate Fo-by-rule, based on the observations of Chapters 5-7. The model is structured into a 'high-level' system representing the phonological Fo effects and a 'low-level' phonetic system. Finally, Chapter 9 presents a summary and reviews possibilities for future research.
2) Perception and Control of Fundamental Frequency

2.1) Pitch

Fo is one of three acoustic features (duration and intensity being the others) of speech that can be directly related to the perceived suprasegmentals. As with many psychological phenomena, the mapping between the physical and perceptual domains in speech is not a simple one. While pitch, length (or rhythm), and loudness are often referred to as the perceptual attributes of the physical features of Fo, duration, and intensity, respectively (Fry, 1968; Lehiste, 1970), the relationship is a nonlinear one with cross-factors.

In voiced speech "the principal correlate of pitch is the fundamental frequency of the periodic sound . . . the frequency of vibration of the vocal cords" (Fry, 1968:374), but intensity and duration are other contributing factors. "With pure tones in a certain range of frequencies, the pitch may be changed by altering the intensity;" however, this has not been shown for complex tones of the type present in speech, so "the 'pitch-intensity' effect is not likely to play any part in speech perception." Duration "can influence the pitch of sounds . . . but only within a restricted range of comparatively small durations," and thus "this effect too is unlikely to have any importance in speech" (375). The relatively direct relationship of pitch to Fo and "the complexity of pitch patterns used in language" (O'Connor, 1973:102) made Fo the most attractive of the 3 suprasegmental correlates to study; however, the relationship, while monotonic, is not linear: "Subjective pitch . . . increases less and less rapidly as the stimulus frequency is increased linearly, and more and more rapidly as the
stimulus frequency is increased logarithmically" (Lehiste, 1970:65).

2.1.1) Relationship of Fundamental Frequency to Pitch

That the linguistic content of an utterance can affect pitch was illustrated by the failure of linguists to accurately transcribe pitch with Fo (Lieberman, 1965:45-7), as compared with much better correlation when simple synthetic vowel stimuli were used (49). 't Hart and Cohen found that "sometimes substantial Fo changes do not give rise to overall changes in pitch perception," and that "the extent of Fo changes as such is no reliable measure for their perceptual relevance;" they suggest that "the listener interprets what he hears in terms of a limited set of recognizable patterns ... perceptual units in some sense," rather than there being a "1:1 relationship between voice periodicity and the perception of speech pitch" (1973:310).

In a pitch-matching experiment, Collier found that "listeners manage to measure pitch in segments where the Fo cannot be extracted" physically, and that "there is a striking discrepancy between the measurement of pitch and that of Fo at the end of [an] utterance" (1972:49). In a similar experiment, Root found that "people tend to miss short glides, tend to average out irregularities, and tend to hear short syllables as unipitched" (Peck, 1969:8). Flint found that pitch perception in "long syllables" in normal speech "corresponded generally to the frequency pattern," but that "if the frequency variation was not sufficient to effect contrast" or if the syllable was "less than 0.09 sec," "the auditory perception was of a single pitch level" (1970:332).
2.1.2) Smoothing and Quantization

Rosenberg found that "the pitch contours for vowel sounds presented in isolation can be smoothed such that most of the period-to-period fine structure is removed with little discrimination from the natural. Apparently, even more pitch smoothing can be tolerated for vowel sounds imbedded in sentences," but that "discrimination for sentence-imbedded vowels depends largely on the total amount of smoothing" in the utterance (1968:1595). Later, Rosenberg et al noted that "pitch-period contours require considerable quantization accuracy but can tolerate a large degree of smoothing" in formant-coded voiced speech (1971:1536). Levitt & Rabiner found that "changing the average value of Fo" in speech results in "a change in voice pitch [which] is perceptible," whereas "smoothing the Fo contour" only changes the "voice quality" (1971:579).

On the basis of such experiments and "well known and generally accepted psychophysical data," Witting proposed that Fo variations in "voiced segments of a smaller duration than 5 csec should be averaged" out as simple levels, and that variations "less than 5 cps should be levelled out" (1962:141), to modify Fo to approach "an approximation to the normal perception of pitch in speech" (144). Noting that "attention is more readily drawn to moving than to stationary objects," he also suggests that a changing Fo "is likely to predominate over a sustained tone" (143).

"The human observer can discriminate between sounds of different pitch much more finely than he can classify them into absolute pitch levels" (Atkinson, 1973:60). O'Connor notes that, although people can distinguish
two tones to within 3 Hz, "any difference of pitch less than about a semitone" is likely not "usable in speech" for contrast purposes (1973:100). (12 semitones = 1 tone, which is a logarithmic Fo measurement corresponding to a doubling of Fo).

2.1.3) Fo Rises and Falls

Peck notes that "perceived variations in pitch are about the same for both widely and narrowly varying fundamental laryngeal frequencies. The same values of Fo will be heard as different relative pitches in different environments. Large rises in Fo caused by closed-glottis consonants are heard as simple high pitches, and a relaxed falling Fo is heard as low pitch. The overall rises and falls . . . are perceived quite well . . . It is the smaller changes in Fo which often escape detection by the human auditory system" (1969:89).

't Hart found in studies of "the discriminability of the size of pitch movements in short [vocoded] speech utterances with single pitch movements as may actually occur in natural speech" that listeners have "a remarkably low sensitivity" (1974:62), and that "discrimination of the size of falls was found to be about half as accurate" as compared to rises (with medians of 1.5 semitones for rises; 3.0 for falls) (58).

Noting that "relative or dynamic changes in Fo are more important than absolute pitch levels in determining stress and intonation contours," Klatt studied "aspects of pitch discrimination in speechlike synthetic stimuli" (1973:12). He found that the JND's for "a change in the Fo of a steady
synthetic vowel with constant Fo" (0.3 Hz) and of a vowel with formant motion (0.5 Hz) were much better than that of "a linear ramp Fo contour" (2.0 and 2.5 Hz, respectively). On the other hand, "discrimination of difference in rate-of-change of Fo in ramp Fo contours is very good:" with a slope near zero, the JND was 12 Hz/sec; near -120 Hz/sec, it was 32 Hz/sec (12). In a finding similar to 't Hart's, Klatt notes that "it is far more difficult to detect an average frequency difference or a difference in rate-of-change of Fo if the change occurs in a descending ramp Fo contour" (12). Noting that "the information bearing aspects of Fo" may be organized in a type of "multidimensional encoding," he suggests perceptual "oppositions of the following general types:" average Fo being high, mid, or low; Fo rising, falling, or remaining steady; and Fo having a fast or slow rate of change (13).

Noting that "the ear perceives [an Fo] tone-switch as a continuous transition" in pitch (1970:13) and that it "cannot be distinguished from natural glides from one pitch to another" (57), Isačenko and Schädlich used vocoded speech in their perceptual experiments and claimed that "certain typical 'intonation patterns' of German, which . . . [are] syntactically relevant . . . , can be represented by the alternations of TWO AND ONLY TWO tone levels (12). They found that, with their "monotonised speech material," "discrimination begins at an interval of 6 cps, . . . in the region of a semitone," and that such an interval "in connected human speech . . . is sufficient to constitute relevant pitch-configurations" (18). It is unclear how relevant this study is to English intonation since, in English, "the most frequent secondary accent type is the rise-fall," whereas German usually maintains
"a relatively high pitch level until the end" of a section of speech (Anderson, 1972:839), and furthermore the two-level vocoded utterances "sounded not like speech, but like chanting or singing on only two different notes" (840).

2.1.4) Summary

The perceptually-relevant aspects of Fo are likely to be the broad Fo variations, which are most easily perceived by a listener. Features of the type: rise-level-or-fall, fast-or-slow change, and high-or-low, are the Fo primitives used in the analysis of this thesis because they appear to be controllable by the speaker and perceivable by the listener. Perceiving rates of change as being fast or slow and levels of Fo as being high or low requires evaluation of the Fo contour in a relative manner; it appears that the listener can 'normalize' to the different ranges and levels of Fo used by various speakers, and thus relative Fo variations and levels are important.

Fine-grain Fo variation has been mostly ignored in the following since the above evidence points to the allowability of smoothing of Fo contours with little change in pitch perception. However, while smoothing was allowed, high quantization was needed in the above speech synthesis experiments. Thus, the amounts of Fo changes are important parameters in the ensuing Fo analysis. Special attention is given to Fo rises and falls, since moving Fo patterns are likely to attract the listener's attention more than steady Fo. Finally, Fo rises appear more important perceptually than falls, because discrimination in their sizes was better than among the falls.
2.2) Intonation and Stress

2.2.1) Intonation

The perceptual features of pitch, length, and loudness contribute to the phenomena of stress and intonation. Intonation involves the perception of the prosodics over the course of an entire utterance, while stress concerns a more local perceptual phenomenon by which certain 'stressed syllables' are highlighted in contrast to immediately surrounding 'unstressed syllables.' Crystal points out that "intonation is a linguistic category, not a physical one" (1970:84), which "is seen not as a single system of contours or levels, but as a complex of features from different prosodic systems, primarily pitch range and direction" (78); other definitions of intonation include: "the use of tonal features to carry linguistic information at the sentence level" (Lehiste, 1970:95), "certain pitch movements [that] recur in patterns in connected speech" (Adams, 1969:127), and "the combination of pitch contours, pitch levels, and prominences that occurs when a sentence is spoken" (Rabiner et al, 1969:93).

Gårding & Abramson investigated some aspects of intonation perception, and found that "pitch patterns provide the most important cues to intonation types" (1965:63), with listeners having "100% agreement on the matching of real and synthetic" versions of utterances with 4 different Fo contours (64). They also found that "minor temporal changes" and approximating the natural Fo contours by "straight lines instead of smoothly undulating lines which are characteristic of pitch patterns" "did not have any effect on the identifications" of the 4 contours (66). In particular, combining successive level
and sloping Fo lines into one sloping line "did not have any noticeable effect" (67). In discriminating among the 4 contours ("statement," "yes or no question," "anger," "delighted surprise" (62)), they found that "the difference between them seemed to reside mainly in the pitch movement of the last syllable" (67), and concluded that "the important features of [their] synthetic contours . . . can be described in terms of rectilinear movements between three pitch levels" (79).

2.2.2) Stress

There are two types of stress: **lexical** (or word) stress and **sentence** stress. Every word has one syllable (and sometimes a second lesser syllable) denoted as 'lexically-stressed,' which, when uttered in isolation, receives a type of phonetic prominence (or 'stress'); "this concept of word stress is essentially morphological" (Bolinger, 1958a:113), and refers in an utterance "not to anything phonetically manifest but to a potential" (1961a:313) or "an abstraction" (Pilch, 1970:99). Thus, "a distinction must be made between the potential of a syllable to bear this pitch accent [i.e., stress] and the actual manifestation of the pitch accent" (Ohala, 1970:111). "English words typically have but one potential for pitch accent . . . . Which element will lose the potential answers to intertwined mechanical and semantic forces" (Bolinger, 1965:71), which are investigated below.

Thus each word has a 'potentially-acceptable' (PA) syllable, and, in an utterance, one or more of these PA syllables receives 'sentence stress,' an actual phonetic realization of prominence. Referring to this type of stress
(which is what 'stress' will mean in this study), Ohala notes that "the real physical correlates of stress are multiple and complex," but that "manifestations of stress serve a very important role in speech" (1970:111). Lehiste also notes the lack of a "one to one correspondence between stress and any single acoustic parameter" (1970:110). Gaitenby refers to "stress" as "the property that endows sequential syllables with differentiating grades of acoustical prominence" (1975:137). Morton & Jassem use "stress" as a general term to describe a structurally significant phonetic entity, identifiable and definable at any level of speech communication: the psychological level of the speaker, his neural and articulatory level, the level of the sound wave in the transmitting medium, as well as the perceptive and higher analytic level of the hearer" (1965:161). "The phonemic pitch assignment can be checked by ear, but the stress assignment cannot [because] syllable stress is an abstraction . . . It cannot be correlated with observable phenomena on a 1:1 basis" (Pilch, 1970:85).

Fonagy claims that "stress is not to be identified" with relatively higher level or longer duration (1966:234), but rather is "conditioned essentially by pitch patterns simulating greater effort" (243). Noting that in stress one can "assume that articulatory effort is involved" and that "effort can readily be associated with pitch rises, and less easily with pitch falls," van Katwijk proposes that "although a fall is a physical product of physiological relaxation [see 2.5] . . . it is a physical cue for the physiological effort that did take place." When an Fo rise and subsequent fall are well separated in time, "then the fall, as a secondary cue,
will 'suggest some virtual rise'" and still be perceived as stressed (1972:72).

Umeda defines stress as a "perceptual event" (1975:18), which is "continuous in degree" (25) and "provides the listener with structural information about the message" of a sentence via a "promotion-demotion among units" of the sentence (8). Stress is "a resource for making the listener understand a given word" (Coker et al, 1973:295), and "an abstract entity . . . indicating the relative importance of different syllables." "Prominence," sometimes used synonymously with stress, indicates "the relative perceptual importance of syllables." "Prominence effects occur primarily during the vowels" (Rabiner et al, 1969:93); Denes noted this relationship also: when a "syllable has an initial or final voiced consonant, . . . there is a marked tendency for the characteristic change in Fo to be confined to the vowel part," and Fo "tends to take up some middle value during the consonantal segment" (1959:111). Indeed, Léon & Martin claim: "In general the consonants do not affect the perception of the melodic [pitch] curve . . . The ear seems to disregard them in interpreting pitch" (1972:44). However, while making no claims about pitch, this thesis found that substantial Fo changes __did__ occur during consonants.

2.2.3) Acoustic Correlates of Stress

Several studies have attempted to find acoustic correlates of stress, being mostly "concerned with the influence of duration, intensity, Fo and spectrum variations on stress judgments by English listeners" (Fry, 1970:403).
Fo appeared to have "an all or none effect," where the syllable on the higher side of a step change in Fo was judged to have stronger stress, without regard to the size of the step (Fry, 1970:403-4). "When continuous changes of Fo were introduced instead of step changes, . . . the Fo cue then outweighed all other cues" (404).

Denes & Milton-Williams agree "that Fo provided the dominant cue in those intonation groups associated with large frequency changes," but that with a combination of intensity and duration in opposition (which may not actually occur in natural speech), "the frequency cues were overpowered" (1962:11; also Delattre, 1965:33). Brown and McGlone found that "Fo is a dominant parameter used by English speakers to denote stress," but that "other parameters [e.g., duration] may be utilized" (1974:974). Lieberman agrees that higher Fo "seems most relevant" among the acoustic correlates of stressed syllables, but claims that higher "envelope amplitudes" are second in importance, and notes a "trading effect" between the two (1960:453). His prosodic feature "prominence" involves "local increases in the fundamental frequency of phonation" (1970:185), while his feature "accent" may be realized by "a sudden decrease" in Fo (187) by which "linguistic stress can be manifested" (199).

"At the acoustic level stress appears to be characterized by a kind of complex trading relationship among [Fo, duration, and amplitude] wherein the predominate feature varies from situation to situation . . . This is at least partially due to the fact that [these features] are conditioned by phonetic
quality and context" (McClean & Tiffany, 1973:283). They claim that "syllable position, speech loudness and rate" also have effects on stress perception (284).

Schramm found that "to create a sense of relatively strong accent on one syllable as opposed to another," all 3 factors of Fo, duration, and amplitude are utilized most of the time, and with "at least 2 of the elements in 99% of the cases examined" in word utterances (Lightfoot, 1970:49; also Medress et al, 1971). Bleakley found in his German analysis that 96% of the stressed syllables "were accompanied by Fo variations which were regarded as perceptible," and 93% of these consisted of an Fo rise or rise+fall (1973:47) but that "perceptible Fo variations do not ... always lead to the perception of stress" (50). He then suggested "that Fo variations are a necessary factor" (58), with the "last perceptible upward or downward Fo variation which is in an opposing direction to the preceding perceptible upward or downward variation" being heard as the main sentence stress (51).

Van Katwijk notes that "pitch variations constitute the necessary and sufficient elements in the control of perceptual stress judgments. Pitch variations appear to overrule all other stress cues easily" (1970b:92). When a syllable contains both an Fo rise and fall, "we have the optimal situation for lending prominence" (1969:71). Mattingly states: "Though intonation and stress are distinct phonological structures . . ., they . . . both involve modulations of the Fo contour" (1968:170), "the chief acoustic cue to stress . . . is the pitch change" (178), and "in the most ordinary case the funda-
mental interrupts its downward trend [i.e., the low declination line (see 2.3)], rises to a peak on the prominent syllable and then resumes its fall" (178). Lea & Kloker look for stressed syllables "to be indicated by local increases in Fo above the falling archetype line" (1975:14), "accompanied by non-falling (or very slowly falling) Fo within the stressed" syllabic nucleus (16).

Lehiste & Peterson found that "primary stress and a change from highest to lowest intonation level" were well correlated in their data (1961:419), and that "both perceptually and physically" the Fo contour on a stressed word went from middle to high to low (M-H-L) levels in sequence (424). This archetype Fo accent obtrusion forms a basis of later analysis in this thesis. Similarly, Peck suggests that "'unstressedness' is shown by Fo falling to and remaining in the bottom range, . . . while 'stressedness' is shown by increasing or holding up the Fo," and that "perceived stress may thus depend on not only absolute values of Fo . . . but also upon their rates of change" (1969:74).

2.2.4) Fo Accent

Bolinger agrees that Fo "is our main cue to stress" (1958a:111), and that Fo "overrides duration" (125). He notes that an Fo "rapid fall after" a syllable (1958a:116) or a positive Fo "upskip" jump to a syllable (119) could mark a syllable as accented, and refers to "PITCH ACCENT, or simply ACCENT, meaning prominence due to the configuration of [Fo]" as the main correlate of stress (127). In accent, the Fo "movement may be UP TO, DOWN TO, or DOWN
FROM the accented syllable" (129) (these correspond with his Accents B, C, and A, respectively (143)). He claims that "differences of meaning attach to: (1) Steep falls as opposed to gradual falls, (2) High approaches to a falling A accent as opposed to lower approaches, (3) In a succession of A accents . . ., the relative height of the peaks. Similarly, for the relative depth of the troughs of successive C accents" (148). Also, the larger of 2 Fo movements ("if more clearly marked") will be "heard as accented" (130), and "upward obtrusions are superior to downward ones" (135). He further describes "pitch accent on a given syllable [as being] abrupt, but not necessarily wide, departures from a reference line" (1970:111).

Atkinson refers to "prominence" as "the phonetic manifestation of main stress:" "Acoustically [prominence's] correlates include an increase in Fo on the prominent syllable, followed by a sharp drop in Fo" (1973:22). He claims that "only the binary distinction (+ Prominence) is possible in terms of Fo" (36), that "the presence or absence of the feature (+ Prominence) on a syllable cannot always be determined on the basis of Fo within that syllable alone . . . The perception of prominence . . . must involve [Fo on the prominent word] relative to the entire contour" (50), and that "only relative changes in Fo seem to be of linguistic importance" (71). In realizing (+ Prominence), "the slope of [Fo] changes (rising vs. falling) . . . cues the prosodic features" (49), and "the exact amount of nature of the [Fo] rise or fall varies considerably . . . Fine control does not seem to be necessary" (58), since "only a binary distinction of stressed vs. unstressed (or + Prominence) serves a distinctive linguistic function" (241). While it may
be that only two levels of stress are realizable (or categorically perceivable) (204), the amount Fo rises and falls is likely a more important signal of the degree of 'informativeness' a speaker attaches to a word than Atkinson apparently feels.

Atkinson further restricts "the primary acoustic cue of prominence" to be a "sharp fall in Fo immediately following the stressed syllable" (233) or "on the end of the prominent syllable" (239), after which "Fo is then held at this low level to the end of the utterance" (233). Similarly, Cushing claims that "primary stress in English is heard when there is a large drop in Fo on the following stressed syllable" (1969:351), and that "primary and emphatic stress are both signalled by large differences" in Fo (356). Atkinson claims that "there does not have to be any increase in Fo on the stressed syllable" (234), nor is "the absolute value of Fo . . . necessarily higher on the syllable with "Prominence"" (239), but that a "rise in Fo on the prominent syllable . . . aid[s] in the judgment of prominence" (237).

He notes however that, in yes/no questions, Fo on the stressed syllable had "a sharp rise up to a maximum which was [then] maintained until the end of the utterance" (245) (see 6.1). In short, Fo undergoes a major change on the last prominent syllable of an utterance, and the direction of the change is conditioned on whether the utterance ends on a low or high Fo (see also Isačenko & Schädlich, 1970:42). In the case of the sharp fall, the drop may occur right after the stressed syllable; whereas, for the sharp rise, Fo may instead jump up right before the stressed syllable (although Atkinson does not note this). The stressed
syllable is always marked by higher $F_0$ than an adjacent syllable: either the transition between high and low $F_0$ occurs within the syllable, or $F_0$ jumps up to or down from it.

Gimson notes that "stress is manifest in terms of a change of level of pitch or direction of pitch in the syllable to be stressed" (1956:99); Morton & Jassem agree that "it is not [Fo's] height that 'signals' stress but the change of its direction" (1965:162), and that "changes in $F_0$ from the standard or 'context' frequency result in a stress marking on that syllable whose fundamental has been changed" (178). They also found that a sloping $F_0$ was more effective than a step change in $F_0$, especially when $F_0$ was falling (173), and that rises were more effective than falls. In addition, they found a type of 'all-or-none' effect in which 25% and 58% changes in $F_0$ were equally effective in marking stress (but both were better than a 9% change) (174). Finally they noted "pitch to be the pre-dominant acoustic parameter related to stress . . . in 3 rather distantly related languages (English, French, Polish)" (163). Delattre claims pitch to be important in German and Spanish as well (1965:33).

"Since there is a general tendency for $F_0$ to fall during an utterance, it is likely that a fall in $F_0$ would need to be somewhat larger than a rise to be perceptually prominent" ('t Hart & Cohen, 1973:46). Collier quotes as "rules of thumb" for "prominence-lending" $F_0$ movements that an "abrupt rise" in $F_0$ utilizes "a 25 to 35% $F_0$-increase every 100 msec," while an "abrupt fall" is steeper, with a "40 to 50% $F_0$-decrease every 100 msec" (1972:71), and agrees that "pitch falls are less effective in making a syllable prominent than rises" (73).
Stress can be also marked by a more gradual Fo fall than adjacent unstressed syllables have; however, in this case, the stress is a secondary, not a major, one. Mattingly's system, for example, included "a tendency for Fo to fall more gradually during the stressed syllable than during other syllables" (1966:8). Similarly, Fonagy has noted that, if Fo does not rise in a stressed syllable, it "usually falls less steeply" (1966:241). Lea & Kloker's system, in its back-up search for stressed syllables, looks for a section of speech "with nonfalling (or at least not-very-rapidly-falling) Fo" (i.e., no "more than 2 eighth tones [= 1/2 semitone] per" 50 msec) (1975:15).

2.2.5) Summary

Certain syllables in each utterance are selected by the speaker to have sentence stress, and this is phonetically manifest (among other ways) by the lexically-stressed syllables of the chosen words receiving larger Fo 'accents' than the other syllables in the utterance. This accent is realized most often by Fo rises (since the initiation of an Fo rise on a syllable always marks it as accented), but also by Fo falls; for an Fo fall to mark a primary accent, it must have a steeper slope than that of adjacent syllables, to distinguish the accent fall from the 'normal', gradual Fo fall on the unaccented syllables of the utterance.

In several languages (including English), Fo provides the main acoustic correlate to intonation and stress. Although there is a trading relationship among Fo, duration, and amplitude, increases, step changes, and rapid falls in Fo have stronger effects than duration or amplitude in marking a syllable
as accented so that the listener perceives it as stressed. While there is some evidence for a binary (or 'all-or-none') distinction between stressed or unstressed syllables, this does not mean that there is a simple threshold in Fo patterns which clearly divides syllables into the 2 categories, or that the amounts of Fo rise and fall, once past a threshold, are irrelevant. On the contrary, stress and Fo accent can both be considered continuous. The evidence indicates that the larger an Fo deviation (change in direction or level of Fo) from a baseline pattern, the more likely the syllable on which the obtrusion occurs will be perceived as stressed. Among the types of Fo deviations, upward changes or rises mark stress better than downward changes or falls, and sloping Fo stresses better than step changes in Fo. Bolinger's finding that the relative height of peaks of Fo are important perceptually led to the use of Fo 'differentials' between peaks in the analysis below.

The basic form of the Fo obtrusion to mark accent was described as an M-H-L pattern, or a local increase in Fo above a declination line; this fundamental pattern is used in the analysis below. While rapid rises and falls or step changes in Fo seem to be the primary means to mark stress (e.g., Bolinger's Accents A, B, and C), slowly-falling Fo can be used in certain contours to mark a secondary form of stress.

The form of data reduction performed on the Fo contours below is partially based on the observations above that smoothing an Fo contour, especially the linearization of Fo patterns and approximating a level line and a sloping line as one sloping line, has little effect on intonation
perception. Also, the observation that the perceptually-important changes occur during the vowels rather than the consonants led in part to the division of Fo contours (for analysis purposes) into alternating sections of vowels and consonants.

2.3) Perceptually-relevant Fo Movements

2.3.1) Basic Patterns

In a series of experiments with Dutch speech, 't Hart, Cohen, and Collier have attempted to "establish those pitch movements that are interpreted as relevant by the listener," with the assumption being that "these relevant pitch movements are related to corresponding activities on the part of the speaker" and that they can "be characterized by discrete commands to the vocal cords and should be recoverable as so many discrete events in the resulting pitch contours" (Cohen & 't Hart, 1967:177). Using a form of vocoder called the "Intonator" (179), which enables replacement of an original Fo contour in a natural utterance with another Fo pattern, they asked listeners to judge various synthetic Fo shapes. They postulated three classes of phenomena of Fo: 'major' and 'minor' Fo movements, resulting "from the speaker's commands" (183) (referred to in this thesis: 'high level' Fo effects) and 'micro' Fo patterns, "which are solely a consequence of physically determined factors" (183) ('low level' Fo effects).

In the 'major' class they put the Fo pattern of "declination line," "a gradual fall-off" in Fo of about 3% every 100 msec (184), which formed
"an average reference voice level" as "a way of relating up or down excursions" to such a baseline Fo. They noted that this line "corresponds very well with the running down pattern that Bolinger suggests as a language universal in pitch contours" (187; Bolinger, 1964:835).

They note "the importance of the non-distinctive characteristics of intonation," objecting to the almost "exclusive attention being paid to the distinctive function of intonation" (189). In comparing Fo and pitch, they found that "presumed pitch levels extending over entire syllables" did not always correlate well with Fo, that perceived high pitches often corresponded to "rapid falls" in Fo, and that the "declination line" "seems to elude normal observation" (189).

They further note that "without changing the perception of intonation, the greater part of the natural pitch movements in an utterance can be replaced by . . . the declination line whereas a limited number of other movements may not be smoothed out with impunity," but can "be stylized into rather steep, simple, standardized rises and falls," called the "perceptually relevant pitch movements" (PRPMs) (1973:310). To determine these PRPMs, they had "the Intonator perform the smallest number of such movements as are needed to achieve . . . a resemblance [between the natural and Fo-altered utterances] which is satisfactory according to a judgment obtained" by listeners told "to concentrate on the detailed melodic aspect of intonation while making abstraction of any relation to the verbal information" (311). Thus "the deletion or the undue insertion of any PRPM causes a clearly
audible change in the perception of the pitch contour as a whole" (312).

2.3.2) Types of PRPMs

They distinguished a number of PRPMs: 2 types of declination line (high and low), 2 rises (a prominence-lending one ("1"), occurring early in the syllable; and a non-prominence-lending one ("2"), "occurring at the end of the very last syllable of an utterance"), and 3 falls (a prominent one ("A") late in the syllable; and 2 non-prominent ones: one occurring before or early in the syllable ("B"), but falling not as far as the prominent one, and a gradual fall ("D"), which "extends itself over all syllables between two prominence-giving rises" (324). (This gradual fall likely corresponds with the exponential fall-off that frequently occurs in English Fo patterns after an Fo peak.)

Collier "hypothesized that Fall D was a free variant of Fall B," and concluded that these "two types of non-final fall are perceptually more or less equivalent" (1972:82). He further noted a "tendency of Fall B to occur almost immediately after the rise," with its major function one of "bringing the pitch back to the declination level" without marking the syllable it occurs on as prominent, and found "its position is therefore limited to inconspicuous syllables or voiceless segments" (83).

Cohen & 't Hart claim that "the slopes of rise and fall" do not play "a decisive part in the pattern. It is rather the location of these movements that is highly critical" (1967:188); "differences in excursion may . . . be regarded as variations within a given type of rise" or fall (Collier, 1972:
"Since the tolerance is rather large with respect to excursion and duration, the most relevant perceptual difference is one between 'abrupt' and 'smooth' rises" and falls (62), with abrupt changes occurring within one syllable and smooth ones over several (63). "Only slight differences in timing give rise to clear perceptual effects, swinging the listeners' judgments from prominence to non-prominence," and vice versa (t Hart & Cohen, 1973:315).

In Dutch, van Katwijk & Govaert found that Fo rises should occur early (and falls late) in a vowel to lend prominence to the syllables in which they occur (1967:115) (van Katwijk suggests a rise "should start at ca 50 msec before the onset of the vowel" and a fall "ca 50 msec after the vowel onset" to lend prominence (1969:70)), and found "rises to be more effective in lending prominence than falls" (1967:117). In interpreting perceived prominence on the first of a series of vowels in an utterance, where the first had no actual Fo rise, they theorize "a (virtual) rise," which lends prominence to a syllable when Fo undergoes a positive Fo jump prior to the onset of voicing (115). Collier notes that "the phonematic structure of [a] prominent syllable does not significantly influence the location of the [most prominent] pitch rise," and that "subjects tend to relate [the pitch rises] position to the vowel onset and not to the beginning of the syllable" (1970:83). He also notes that the position of the peak of an Fo rise is more relevant for prominence than the onset of the rise, and that longer rises have later peaks (relative to the vowel onset) (84). t Hart & Cohen regard "an upward jump of pitch in case the voicing is interrupted" and "the
upward pitch glide which can actually be measured if the voicing is continued" as perceptually equivalent (1973:311).

2.3.3) Larger Patterns

Collier concludes that "listeners can consistently perceive pitch features in spoken utterances" (1972:159), and that "intonation manifests itself as a succession of discrete pitch movements," which perceptually are the smallest units, each of which "can be defined as a unique combination of perceptual features such as: gradualness, position, excursion, prominence" (160). He further claims that "the perceptually relevant pitch features ... can be related to specific physiological mechanisms at the subglottal and laryngeal level" (160).

Noting that "most of the pitch variations within utterances appear to be free variants of a limited number of basic intonation patterns" (Collier, 1974a:24), the Dutch group have postulated an inventory of such essential F0 contours consisting of certain sequences of the PRPMs "that are capable of making an utterance sound intonationally complete" (1972:79). Among the patterns they claim exist for Dutch is the "hat" pattern: upon a low declination line is superimposed a Rise 1, a period of high declination, and then a Fall A (80). "In one accent utterances the two pitch movements fall on the same syllable," while with two "the rise is situated on the first and the fall on the second" (81).

Collier found that subjects were "capable of noticing intonational re-
semblance and difference between utterances" with the "hat" and 2 other patterns (96), although such discriminations were only in the 85% range, and he conceded that "even though the subjects had been instructed to concentrate on intonational resemblances, the actual grouping could possibly be based on other criteria, such as correspondences in syntactic structure, lexical content, voice of the speaker, etc." (97). Indeed, Umeda states: "When perceptual judgments are involved," one "has to wonder what acoustic characteristics have triggered the listener's perception" (1975:19). Such difficulties appear to enter into most perceptual studies which attempt to relate Fo patterns with intonation and linguistics.

In asking listeners to sort English utterances "into groups of intonation types," Gårding & Abramson found that less than half of the utterances were grouped into the same classes by 80% or more of the listeners (1965:63). Collier points out that "subjects easily agree that two contours are the 'same,' but . . . are less consistent in judging 'different' contours," and that "the degree of confusion between particular contours is variable" (1972: 102). So his conclusions that "intonation pattern recognition seems to be largely categorical" and that his "basic pitch patterns seem to correspond to . . . linguistically functional intonation patterns" (103) seem premature. He gives no firm reason for choosing the 3 patterns mentioned above, and leaves the impression that other patterns could be discriminated as easily as these 3. A more accurate statement would be that "not much is known in detail about the perception of intonation. Specifically, it is not known whether the linguistic features of intonation are perceived 'categorically'
... or whether fine discriminations can be made and used linguistically" (Atkinson 1973:62).

2.3.4) Summary

While there is little evidence for the categorical perception of the Dutch group's Fo 'patterns,' their observations as to the existence of 2 declination lines and of 2 types each of Fo rises and falls (one lending prominence to the syllable on which it occurs, and the other not) have more foundation, and are likely applicable to English speech and to the analysis of Fo in this thesis. The data below support their observations as to the importance of the location (within a syllable) of an Fo movement as to its potential for marking that syllable as accented. Their 'hat' pattern is similar to one of the Fo patterns found in the data below, but the 'hat' was not an adequate model for many of the observed patterns.

Their division of Fo phenomena into 'major' and 'micro' effects parallels the division used in the algorithm of Chapter 8. The Fo analysis in this thesis was guided by their observations: that non-distinctive Fo is important (hence the entire Fo contour was analyzed), that there is a large tolerance in Fo patterns which allows stylizing without perceptual changes (hence the analysis was done in terms of basic rises and falls, ignoring fine-grain changes), that slopes may be largely irrelevant (hence most analysis concerned amounts of Fo change, not slopes), and that voicing interruptions had little perceptual effect (hence Fo changes were considered equivalent whether actual rises or step jumps).
2.4) Contrastive and 'Normal' Intonation

2.4.1) Contrastive Stress

There appears to be a special type of stress in speech, called 'contrastive' or 'emphatic,' which involves a larger than usual amount of accent: larger Fo obtrusions, longer durations, and louder syllables. This contrastive stress (CS) is not simply a heavier than normal stress, which would be used to indicate the greater importance of a word, but rather is used to more clearly discriminate among a small number of alternatives, previously mentioned in the discourse (i.e., old information), or to contradict an assumption the speaker believes the listener to have. Nickel claims that sentences with "contrastive accent . . . correct antecedent sentences paradigmatically," and are "often used in dialogue" (1970:672); and such sentences "often superimpose the contextually conditioned regularities of thematization and rhematization" (673).

Isačenko and Schädlich refer to CS as what happens when "the main stress does not fall on the word predictable by the grammatical rules" (1970:25), or when the main Fo "tone-switch [has been] shifted from its normal syntactic position" at the end of the sentence (47). Atkinson thinks that the differences "between 'emphatic' and 'normal' stress are differences in degree of the same feature and not differences in kind of feature" (240): "if 'emphasis' is involved, there is a tendency for heightened Fo on the prominent syllable, while Fo for the rest of the contour is lower than in a similar sentence without emphasis" (239). In addition, the value of the Fo slope on a syllable with CS increases (Cohen & 't Hart, 1967:190).
In CS, Bolinger notes that "two or more items are counterbalanced and a preference indicated for some member or members of the group," that Fo makes "the major contribution" to CS (1961:101), that CS is realized by lowering accent on the other words in the utterance, as well as raising accent on the CS word, and that "when a word that normally gets an accent fails to get one, . . . usually . . . some other word has become contrastive." However, he claims that the Fo accent used in CS "is not phonetically definable. It is the same as other highlighting by means of pitch accent, though it leans to the extreme of scale" (116; also Peck, 1969:100).

While some authors would agree with Bolinger (e.g., Schmerling, 1974a; Berman & Szamosi: "the difference between a contrastive and a non-contrastive reading is not so clear cut" (1972:314)), others might disagree: "Among English accentual phenomena there is a clear systemic contrast between normal accents and emphatic ones" (Vanderslice, 1970:142), where "emphasis" has "the phonetic correlate of . . . an extra pitch obtrusion on a particular syllable" (Vanderslice & Ladefoged, 1971:8).

Normally, function words receive no accent, but any word or "any part of a sentence may receive contrastive stress" (Hutchins, 1975:115). "Emphatic sentence stress . . . may be given to any syllable which is to receive exaggerated attention" (Lightfoot, 1970:52). Bolinger notes such accenting on function words, such as relative pronouns and auxiliary verbs, "as a means of affirmation" (1958a:136). Wang separates "emphasis" from "contrast" in that "emphasis . . . distinguishes a proposition from its negation, [and]
usually affects Fo at a fixed internal position," viz., "it raises Fo on the first stressable syllable in the verb phrase", whereas "contrast . . . distinguishes the selection of one linguistic element from others of similar category, [and] can . . . affect Fo anywhere" (1972:488).

2.4.2) Semantic Disambiguation

Referring to disambiguation among possible alternatives via CS, Daneš notes: "it would be wrong to claim a direct relation between intonation and the meaning of a word. Intonation . . . only signalizes contrastive emphasis, and since we do not anticipate emphasis on one of the two possible meanings, the possible ambiguity is resolved" (1960:52). Pierce refers to CS as an "overly strong stress [which] can be shifted from one morpheme to another in a given sentence to change the emphasis" (1966:62), but insists that "it only serves to call attention to a given part of the sentence, rather than signal a definite change in meaning," and therefore is not distinctive or "phonemic in English" (63).

2.4.3) 'Normal' Intonation

Closely related to CS is the concept of 'normal intonation,' the intonation a speaker would use in ordinary circumstances, with no particular emphasis on any word. Pope defines "normal intonation contours" as "those assigned to new utterances with quite a bit of consistency among speakers" (1971:72). Coker & Umeda "speculate . . . that stress is perceived relative to a mental image of how the sentence might 'normally' have been uttered. If the sounds . . . agree with the image, then we perceive mainly the
distinction between substantive and functional . . . If the sounds disagree . . ., we perceive mainly the differences" (1971:140).

Chomsky notes that "the concept of 'normal intonation' is far from clear," but refers to it as the situation where "special grammatical processes of a poorly understood sort" have not applied in "marking certain item . . . as bearing specific expressive or contrastive features that will shift the intonation center" (1971:199). Similarly, Stockwell claims the existence of "a 'neutral' or 'normal' or 'colorless' intonation contour for any sentence, serving as a baseline against which all other possible contours are contrastable" (1971:25), and says that CS is formed by a relocation of "the center of the intonation contour" (26) (i.e., "the point at which the pitch contour sharply changes" (45)), and that such a relocation "produces a reading which must single out for emphasis . . . some otherwise unpredictable item for stress/pitch highlighting" (44).

Schmerling explores the notion of "normal stress" and concludes that it is "a particularly murky concept" (1974b:66): "if normal stress means that assigned to a contextless situation, then it must mean the stress assigned to a sentence with no semantic representation" (71). She notes that it is often "assumed that non-normal stress is to be described as a deviation from the norm" (66), but that "there is apparently no direct relationship between amount of deviation from the 'norm' and the number of special assumptions made by the speaker of a sentence" (71) ("some utterance-tokens involve more special assumptions than others" (72)), and "there is no such thing as a
totally neutral context" (72).

2.4.4) Main Stress or Focus

Several authors have noted that the 'focus' of a sentence or the primary sentential stress usually comes late in the sentence, on the last content word, in normal intonation (e.g., Halliday, 1967:38; Flanagan et al, 1970:39; Isačenko & Schädlich, 1970:24, 59; Wode, 1972:1060; Hirst, 1974:9). This phenomenon is likely related to the basic distribution of theme and rheme (Daněš, 1960:46), since the more important information comes late in the normal sentence. For instance, Bolinger notes that "English tends to shift the major stress toward the end" (1958b:77) and "the main accent goes, normally, on 'the last stressable constituent'" (1972a:644), and suggests that "stress is climactic, ... we attribute extra intensity to the position at the end, even when it lacks it phonetically" (1958a:125); while Atkinson claims that the listener "automatically assigns main stress to the last element" even if no "sharp [Fo] fall occurs in the utterance" to mark it (1973:234). On the other hand, there are many utterances in which "the primary stress occurs well before the end, ... on the item that carries the most information" (1958b:77); in such utterances, "there seems to be a constraint that the rest of the [Fo] contour contain no further Fo inflection" after the main prominent syllable (Atkinson, 1973:250).

This tendency for late main stress has been formalized in certain linguistic rules, such as the "Nuclear Stress Rule" (NSR) (Chomsky & Halle, 1968), which assigns higher stress to the rightmost stressable item in a
given phrase or sentence domain, or the "Nuclear Accent Rule," which assigns main accent "to a vowel if it is accented and there are no later accented syllables in the sentence" (Vanderslice & Ladefoged, 1971:16). Indeed, Bresnan has attempted to account for sentences in which the main stress was not on the final sentential item, by ordering the NSR "after all the syntactic transformations on each transformational cycle" (1971:258), so that the "fundamental stress relations are preserved through syntactic derivation" (1972:327) and the underlying rightmost stressable element would receive the main-stress.

The main problem with these attempts to find algorithmically the location of the 'main sentential stress' and indeed the whole idea of a tendency toward the late occurrence of such stress is that, contrary to Atkinson's (among others) claim that "one and only one element in an utterance may receive main-stress" (1973:250), it is far from clear what 'main stress' is, how often if occurs, and whether it can be distinguished at all from ordinary sentential stress. In particular, many of the sentences quoted by Bresnan (1971; 1972) and her critics (Lakoff, 1972; Berman & Szamosi, 1972; Bolinger, 1972a) are dubiously marked as to where 'main stress' should be placed; to support one particular argument or another, each gives sentences with main stress marked, in which a main stress could just as easily be located on another word, thereby weakening their theories.

In an utterance, certain of the words (usually the content words) receive Fo accents on their lexically-stressed syllables (which are perceived
as sentence stresses). A case could be made for a binary distinction between accented and unaccented syllables (i.e., whether or not their words receive sentence accent), and it is true that among the accented words, ones with larger Fo accents are perceived as more prominent. However, whether one particular word stands out from the other words with sentence accent in all cases is not obvious. Certainly, in sentences with CS, the heavily accented word with CS stands out as the 'focus' or 'main stress,' but in most 'normal' sentences with more than one accented word, it is much in doubt whether one word will always (or even most of the time) be clearly more prominent than the rest. Factors like new/old information and discourse context have a direct bearing on which word may be the most prominent; if there is only one new information word in a sentence, then it receives the main stress, but if more than one word is new and eligible for accent, the speaker is usually free to distribute his Fo accent among them, and 'main stress' is not determinable.

Bolinger points out other problems involved in any "systematic structural explanation of stress assignment" (Bresnan, 1972:337). Stress placement will always be affected by non-syntactical factors such as: "the point of information focus," accent being given to a "semantically richer verb," and "less predictable verbs" being "less likely to be de-accented" (Bolinger, 1972a:634). "The speaker adjusts the accents to suit his meaning" (635); "it is the relative informativeness or unpredictability of the meaning in the context" that governs accenting (637). Summing up, he claims that "the distribution of sentence accents is not determined by
syntactic structure but by semantic and emotional highlighting. Syntax is relevant indirectly in that some structures are more likely to be highlighted than others." However, such a description, in "statistical terms" (644), would definitely be of use in a synthesis-by-rule algorithm, in which the desired output is one acceptable Fo contour; there, certain subtleties of stress can be overlooked. And that is what attempts (such as Bresnan's) to assign stress placement are best suited for. If certain syntactic structures or rules can illustrate a tendency toward more accent on one word than another, they can be incorporated into an Fo-by-rule scheme, along with rules concerning the tendency for heavier accent on the 'less predictable' and 'semantically richer' words, to yield a satisfactory Fo output.

2.4.5) Summary

'Normal' intonation has been described as the intonation on a sentence spoken with no special assumptions or emphasis. In such an utterance, the 'focus' or 'main stress' usually falls on the last accented word, according to such rules as the NSR. Certain formal attempts have been made to account for utterances where 'main stress' occurs other than late in the utterance; however, these attempts are successful only in the sense that they predict probable locations for 'main stress.' Their failure at discovering a deterministic algorithm lies in the ambiguity of the concept of 'main stress' and in attempting to predict stress location strictly on syntactic grounds. It is essentially the unpredictability of a word in context that gauges its accent (and hence stress); thus semantic factors are clearly as important as syntax. The observations in this thesis have led to
an algorithm, not to predict 'main stress' location, but to predict where the 
Fo accents will be placed in an utterance; the algorithm is not limited to 
syntactic input, but also utilizes semantics and phonetics.

The notion of CS is based partially on the concept of 'normal' intonation, 
in that CS marks a word as more heavily stressed than would occur with 
normal intonation. CS is used to call the listener's attention to a specific 
word or phrase in the utterance (the heavily accented one), and thus any 
word (or even any syllable) may receive CS. No distinct meaning change per 
se is signalled by CS; rather, the speaker calls attention to a word which 
is one among a set of possible alternatives or which contradicts one of the 
listener's assumptions. Increased Fo is used in CS, but since it is unclear 
whether CS is binary or continuous, it is also uncertain how much of an Fo 
increase is needed to change an utterance from having normal stress to one 
with CS. One argument for CS constituting a separate entity rather than just 
a difference in degree is that accents on syllables other than the one with 
CS are reduced in CS situations.

Wang's differentiation of 'emphasis' and 'contrast' claims a separate 
phenomenon for 'emphasis:' unlike 'contrast,' it is restricted to use in 
affirmation or negation, and usually affects negatives and auxiliary verbs. 
That such words do get increased accent in these functions is explored in 
5.1.2.
2.5) Control of Fo

2.5.1) Mechanisms for Fo Control

Several studies have attempted to discover the physical mechanisms by which a speaker manipulates his Fo. The two main factors appear to be sub-glottal pressure (Psub) and laryngeal muscle tension; however, there has been much dispute as to how much (and at what points in an utterance) each of these contributes to Fo variation. (Lieberman, 1967a:104; 1970:191, 200; Lieberman et al 1970a:313, 327; Vanderslice, in Lieberman et al, 1970b:55; Ohala, 1970:23, 76; Öhman, 1967:29; Vanderslice, 1970:140; Collier, 1974:143; 1975:254). A consensus seems to be that muscle activity is the main factor in Fo variation, with Psub in a secondary role (e.g., Atkinson, 1973:131; Perkins & Yanagihara, 1968:252).

Regarding the current study, however, a Lieberman comment is relevant: "When a listener hears ... a fundamental frequency rise he often has no way of telling whether the rise was due to the activity of the laryngeal or the chest and abdominal muscles" (1967b:319). Thus as far as a descriptive model of Fo (or an Fo-by-rule scheme) is concerned, the physiological origins of Fo are not important. Rather, of concern is how Fo can be controlled, how accurately a speaker can manipulate his Fo, and which Fo gestures he is capable of; whether he uses Psub, the cricothyroid muscle, or the sternohyoid muscle to control Fo is not directly relevant here.

Chala notes that "a human speaker can and does 'program' his laryngeal muscles to execute any pitch change whatever, limited only by the intrinsic
mechanical and neuromuscular constraints of the larynx and its muscular and
cartilaginous attachments" (1970:77) (unfortunately, he does not elaborate
on what constraints these impose on Fo possibilities). He claims that, for
Fo rises and falls, "muscular activity is involved in both actions" (80),
but notes the possibility of "greater effort involved in raising pitch as
opposed to lowering pitch" (Ohala & Ewan, 1972:4). Citing a "mimicry test"
as evidence, Shimaoka also claimed "that rising intonation is harder than
falling intonation" (1966:360).

2.5.2) Fo Production Ability

Commenting on a speaker's ability "to signal those small differences in
Fo exemplified by tone systems like Cantonese," Wang claims that a speaker
"must be able to achieve very delicate control over the laryngeal musculature"
(1972:494). Chala & Ewan investigated some limitations on a speaker's abili-
ty to manipulate Fo, and found that speakers, when asked to "sing along"
with alternating high and low tones in an ordinary human Fo range, "seldom"
succeeded "in matching the intended pitch levels," but did manage to "pro-
duce pitch changes over three distinct pitch intervals" (1972:2). In
"shadowing" the abrupt tone changes, subjects were found to have "a marked
tendency for pitch lowering to be faster than pitch raising for a comparable
pitch interval," but "no marked tendency for a pitch change over a large
pitch interval to take longer than a pitch change over a smaller interval for
changes in the same direction " (3). The faster rate for Fo falls may be
related to the necessity for Fo falls to be steep to mark accent, while rises
need not.
In an experiment quite similar to that of Ohala & Ewan, Sundberg found that "the subjects arrived at a frequency agreeing with the ideal frequency within + a half semitone" (1973:41), that "the response time grows with [Fo] interval width, particularly in the case of rising intervals," and that "rising intervals have slower response time values than falling intervals" (42). He also suggested that rapid Fo changes may involve "accelerator" and "decelerator" muscles (44).

In his experiments, Takefuta asked a speaker "to produce, for each sentence, any two intonations, of messages which she thought were contrastive" (1974:22); these utterance pairs "were presented to a panel of listeners," to be judged "same" or "different" (and resulted in a 35%-65% split) (3). Treating an intonation "signal" as "any 'difference found in contrastive pairs of intonation'" and "noise" as "any 'difference found in non-contrastive pairs of intonation'," he found "Fo variation to be the most efficient physical correlate as an intonation signal" (6). Using a somewhat coarse statistical analysis, he concluded that "the mean and the standard deviation" of Fo and the "rate of pitch change" were "not significant as intonation signals" (8), but that the Fo contours could be described in terms of "pitch patterns" each consisting of a succession of 2 or 3 "fundamental pattern features" ("fast rising," "rising," "level," or "falling") (14). In an earlier study, he concluded that "the combined information of pitch pattern . . . and the pitch level measured in 8 contrastive units seem to comprise the primary phonetic signal of intonation, perceived by average American listeners" (1970:882).
2.5.3 Fine-grain Variations in Fundamental Frequency

In describing successive Fo periods in speech, Lieberman found three "distinct types of variations:" "undulations about a relatively steady mean period," sections of "quite steady" periods, and sections with "relatively smooth transitions." He found that "the most extreme changes occur at the onset and end of voicing, where differences of as much as 7 msec occasionally occurred" (1961:598); of the 7000 pitch periods examined, "adjacent periods" differed by "greater than 0.6 msec 20% of the time, and greater than 1.0 msec: 15% of the time" (602). In only 14% of the cases did the period durations remain steady in 3 consecutive periods ("within the 0.2 msec quantization interval"); "in 38% . . . , the duration of three successive periods either rose and fell" or vice versa; in 34%, only one pair of the two consecutive pairs was steady; in the last 14%, Fo "steadily rose or fell" (600).

2.5.4) Durational Relationship to Fo

Some authors have linked the durations of syllables to the amount of Fo variation within them, suggesting that a syllable with more Fo movement will have longer duration. Bolinger notes: "A pitch obtrusion requires time for its execution. When the pitch accent is embraced completely by a single syllable, the syllable is lengthened to accomodate the necessary range of pitches," and cites as evidence that "accented syllables are normally longer than unaccented ones in comparable positions within the utterance" (138). Bolinger also notes that, in answer to "Who would do it?", the responses "John" and "John would" are equivalent, but that the latter is necessary if a "tentative" rise+fall+rise Fo contour is used, because "the extra word is
needed to cover the more complex [Fo] undulation" (1964b:29). Similarly, Burgess postulates "a marked lengthening" of syllables which have large Fo rises (1973:320; also Öhman, 1967:34, 52). For Swedish, Carlson et al found that Fo peaks "show positive correlation with the length of the associated stressed vowel" (1972:16) (which is suggestive of relatively constant Fo accent slopes).

A possibly related phenomenon is that of specific Fo patterns adjusting to the number of syllables on which the curve is to be manifest. In describing a fall+rise Fo pattern, Jassem claims that, if the pattern encompasses two syllables, "the first syllable usually carries the fall and the second carries the rise;" if only one syllable, the entire pattern crowds into that syllable; if three syllables, the middle syllable separates the exterior fall and rise by a level medial Fo (1972:250). Similarly, Daneš, referring to Fo contours as marking "distinctive points," says that, if "the distinctive points are more numerous than the syllables," then "the contour has a contracted form;" whereas if "the number of distinctive points is smaller than the number of syllables," it "has an extended form," and "the pitch levels of the 'surplus' syllables are then irrelevant" (1960:39).

2.5.5) Summary

It appears that, while delicate control of Fo is within the speaker's ability, general Fo patterns of the type rise vs. level vs. fall are the ones likely to distinguish various intonations. Lieberman's findings on the amount of fine-grain Fo variation reinforced the decision to analyze Fo in
broader patterns than individual pitch periods. The large Fo transitions that he found at voicing boundaries (which were confirmed in my data) led to ignoring Fo at such boundaries, and concentrating on the smooth Fo variations within the vocalic nuclei.

The observations that Fo rises require more effort than falls, that Fo lowering is faster than raising, and that accelerator and decelerator muscles may be involved are explored further below. The ability of an Fo pattern to expand/contract according to the number of syllables which the contour occupies was confirmed by my data also.
3) **Method:**

3.1) **Procedure**

3.1.1) **Description of Corpora**

Over the course of this thesis research, 8 sets of sentences were composed for the purposes of examining Fo phenomena under controlled conditions in sentences systematically varied with respect to semantic, syntactic, and phonetic factors. The list of sentences in each set consisted of sentences with varied subject matter and syntactic forms, and was randomized to assist the reader/speaker in avoiding a 'list-reading' mode. In several cases, question-and-answer (Q/A) sentence pairs were included among the isolated, context-less ('citation-form') sentences, and short paragraphs were read at the ends of the sentence lists. These paragraphs and Q/A pairs were utilized to observe the effects of context on sentential Fo phenomena.

Each corpus was read by one or more adult male speakers (JA, KS, ML, DK, DO) in a sound-treated room in one session each. The speakers were instructed to read each citation-form sentence independently of the others, and to give a moment's prior thought as to the meaning of the sentence.

In chronological order, the sets were: set A - 229 sentences read by KS; set B - 47 sentences read by JA, KS, and DK; set C - 61 sentences read by JA, KS, and DK; set D - 190 sentences read by JA, KS, and ML; set E - 105 sentences read by JA; set F - 150 sentences read by JA, KS, and DO; set G - 50 sentences read by JA (this list was also repeated in the same session); set H - 189 sentences read by JA. The main speaker (JA) also read preli-
minary versions of sets D and F in other sessions, thus providing 2 examples for his speech in sets D, F, and G. In addition, coherent short stories (discourses), consisting of paragraphs with 4-13 sentences each, and listed in the Appendix, were recorded at the end of the sentence list in sets C, D, and F.

3.1.2) Fundamental Frequency Contour Generation

The recordings of the spoken sentences were processed on a PDP-9 computer to obtain Fo plots, with the use of a hardware Fo extraction device based on an algorithm by Gold & Rabiner (1969). These 'contours' of Fo as a function of time (Fig. 2) contain Fo values every 10 msec (except during the unvoiced portions of speech, where no Fo is plotted, since there is no vocal cord vibration). To facilitate analysis and comparison of the Fo plots, data reduction in the form of linear approximation was performed on each plot; on each syllabic nucleus, each rising or falling Fo movement was represented as a straight line by connecting the endpoints of each Fo excursion. Fo was ignored in the low-energy regions (defined as having amplitude below 40% of the maximum on that syllable) of any voiced consonants adjacent to the vocalic nuclei of each syllable.

It was necessary to ignore certain Fo points at the beginning and end of a voiced segment. During the vowel, the contour was smooth and did not have sudden oscillations (i.e., sudden jumps of more than 8 Hz/centisecond); these quick changes always occurred at the boundaries of a voiced segment, and were eliminated in the analysis (Lieberman, 1961:598). Fo transitions
of a large rate (such as 6 Hz/cs) were not ignored if they were contained within the smooth contour of a vowel or sonorant, and such large transitions did occasionally mark accent.

Thus, the Fo plot produced by computer was hand-reduced by elimination of 'extraneous' boundary points, and what remained was the smooth contours of Fo occurring during the sonorants. These contours were analyzed by fitting them with straight lines (by hand). Since no apparent studies have established any conditioned relationship between the shape of Fo curves (e.g., exponential, linear, polynomial, etc.) and any linguistic or phonetic variables in speech, the smooth undulations of Fo patterns have been reduced in this study's analysis to simpler linear approximations. (Öhman (1967) and Olive (1975) have modelled Fo contours as having exponential and polynomial shapes, respectively, but such patterns have been chosen mainly because they 'fit' the contours, and not for any phonological or phonetic reason). Most syllabic nuclei had Fo trajectories which lay along a straight line, only deviating a few Hz above or below the line.

3.1.3) Choice of Parameters

In light of the findings about which Fo movements were most readily distinguished perceptually and which Fo gestures were produced when speakers were asked to utter different 'intonations,' this thesis accepted the motions of Fo (rising, falling, or level) on each syllable as the most relevant aspects of the Fo patterns. The amounts of Fo rises and falls as well as the synchronization of these movements with the uttered phones were chosen as the
parameters for analysis of the Fo curves. Since these factors appear to be perceptually relevant and mostly under the speaker's control, they were the most attractive measurements for use in reducing the quantity of data present in an Fo pattern. While Fo changes value every period of vocal cord vibration, theoretically yielding up to 20 independent values of Fo in a typical short vowel, for example, actual Fo variation within a phone is considerably restricted, so that a given Fo value is highly dependent on prior values, and Fo patterns (ignoring fine-grain variation) usually form relatively smooth curves.

Since Fo changes (rather than absolute Fo levels) have been linked to listener perception of stress and intonation, and since unvoiced consonants delimit the syllabic nuclei with sections of no Fo, the Fo patterns below are described in terms of how much Fo changes prior to the onset of the nucleus in each syllable, and how much Fo rises or falls during the nucleus. Thus, Fo accent is considered to consist of at least 2 components (Fig. 3): a prior jump or upstep in Fo before the accented syllabic nucleus, and a rise in Fo during the nucleus itself; the terms 'jump' and 'drop' refer to positive and negative inter-nucleus Fo changes, while 'rise' and 'fall' denote nuclear changes (+ for rise or jump, - for fall or drop). 'Rise accent,' or simply 'accent,' when used quantitatively, refers to the sum of the prior jump and the ensuing Fo rise in an accented syllable (AS). 'Fall accent,' or 'descent,' refers to the sum of the Fo fall on the AS after the peak and the ensuing drop to the start of the next syllabic nucleus. For an unaccented syllable (US), the term 'prior descent' is used to refer to
the Fo descent to the **start** of its nucleus. When used quantitatively, 'fall-off' refers to the total Fo decrease on a syllable, i.e., the sum of a prior drop and ensuing fall.

The Fo pattern on a syllable is sometimes abbreviated in the form '(a,b,c,d) e (f,g,...)', where a-d and f-g are signed numbers representing sequential Fo changes. Each parenthesized group of numbers represents Fo changes over one syllable; 'a' and 'f' note the jump or drop in Fo from the end of the prior nucleus to the start of the current nucleus. Ensuing numbers (e.g., 'b', 'c', 'd') note successive rises or falls within that nucleus; 'e' notes the Fo peak attained within the nucleus.

The main characteristic of Fo accent is that it marks the syllable on which it occurs as having an Fo pattern that 'deviates from the norm.' In quantifying such deviations, the amount of the Fo rise or fall on the AS was chosen as the most relevant parameter. For the accent rises, the value of the Fo peak attained was also considered important in comparing the amounts of accent different words received.

Since the Fo trajectory on virtually all syllables can be closely approximated by 1-3 linear segments, a description of the syllable's Fo contour in terms of a prior jump (or drop), the amounts of internal change, and perhaps some slope information, should capture the crucial information contained in the contour necessary for speech synthesis or recognition work, while reducing the amount of information (of which much is redundant) available in
the contour to a smaller set of parameters. What is lost in this sort of pattern analysis is the 'fine-grain' variation (of 1-3 Hz/per period) present in many F0 contours, as well as some minor inflections (such as occur when representing a falling F0 shape containing slight curves as a linear fall). The loss of these factors in speech synthesis is not likely to affect the communication of linguistic information between 'speaker' and listener, in that these factors are probably not directly under speaker control; whereas items such as where to locate an F0 obtrusion, and how high and how fast to raise F0 are likely to be mostly under speaker control.

Since one objective of this research is to describe F0 contours (produced by human subjects) for use in automatic synthesis and recognition schemes, it was considered desirable to use as few and as simple parameters as possible in order to keep the algorithms relatively simple; however, since natural contours are the main consideration, it is not wise simply to view the F0 contour as a secret code, a random mathematical function, or a sum of polynomials just because the computer can easily handle these. It is necessary to consider what the speaker is trying to accomplish with his manipulations of F0 and to also consider the nature of the tools (vocal cords) he is using. A human speaker is physically limited in the types of F0 contours he can produce, and further when uttering normal speech, he only uses a relatively small subset of the possible contours he is capable of producing. Thus, the problem of F0 contour description is not viewed here simply in terms of statistical pattern recognition, but also always keeping in mind what linguistic information the speaker is trying to convey and what
methods he has available to do this via Fo.

3.2) Form of Results

In the following chapters, Fo data are presented in tables for all speakers. In addition, results are presented in typical Fo plots for one speaker (JA) in detail, and for the other speakers to lesser extent. Where significant differences occurred between the contours of JA and the other speakers, mention of the deviations is made in the text below.

3.2.1) Figures

The figures are of 2 types, each with the vertical axis noting Fo in Hz and the horizontal axis representing time in msec. One figure type presents individual Fo contours, each representing a single utterance; in these, the vertical marker notes a 40 Hz division, and the horizontal markers note 200 msec divisions. The Fo values are plotted each 10 msec as small circles, and selected values (peaks and valleys) are noted on the plots as numbers (in Hz). Thick solid lines have been drawn through those portions of the Fo contour that correspond to the syllabic nuclei of the utterance. The second figure type presents averaged, linearized Fo contours; in these, the vertical scale marks off each 20 Hz. Each set of plots has the same vertical scale size, but the time scale has been varied for display purposes. To facilitate comparison in the second figure type, Fo plots for the same and similar sentences uttered by the same speaker have been averaged together, over each linearized Fo movement; these represent Fo patterns after abstraction of the plots into the rises and
falls which characterize each separate contour. (Such averaging of the raw Fo data without time normalization or syllable synchronization would obliterate much relevant information about each contour; however, since the aspects of Fo variation relevant to an Fo-by-rule scheme (i.e., linguistic and phonetic effects) are likely generally preserved in the data reduction (with possible loss of emotional or attitudinal information (Lieberman & Michaels, 1962)), averaging together plots strengthens any conclusions drawn upon each composite plot.)

At the bottom of each figure is an orthographic description of the sentential material for which Fo is displayed in that figure. Since the plots are structured into syllable-by-syllable rises and falls, the orthographic description of each syllable is aligned to be directly under the Fo excursion for that syllable, where possible. Words in quotes indicate the actual words used, whereas unquoted words represent lexical categories for which several different words were used; hyphens are used to separate more than one syllable within a word; syllables in parentheses indicate that some of the utterances for which Fo is plotted in the figure contained those syllables, while others did not; similarly, syllables in brackets indicate disjunctive choice, where each of the utterances for which Fo is plotted contained one and only one of the bracketed elements. Underlined syllables and capital letters (where used to distinguish from small letters) indicate ASs. (The use of the symbol "∅" in brackets indicates the lack of a syllable in that sentence position, in one or more of the Fo plots.)
The separate Fo plots in each figure have been shifted along the time axis for easier visual comparison; where possible, the plots have been synchronized such that the particular syllables of interest are best aligned. Since time normalization has purposely not been used, and separate plots have different durations, there is however overlap in the plots. To aid in locating points of interest in each figure, figures with several plots have been arranged so that similar symbol types (i.e., lines, open or closed symbols) were used for similar Fo plots. In addition, letter-codes occurring immediately to the left of the start of a word's Fo curve help identify the Fo pattern of certain key words in each plot. (The codes are: A - adverb, N - negative, X - auxiliary verb, C - negative contraction, M - class A modal, B - class B modal, P - pronoun, Q - quantifier, and V - main verb. The latter 3 codes are used only when ambiguity might result, whereas the others are used throughout.)

3.2.2) Tables

Each table shows abstracted Fo data for a group of utterances from one corpus set ( 'utterances' in this thesis refer to utterances of one sentence each). Each line in the table exhibits averaged Fo parameters from a group of similar sentences for one speaker. The parameters are: accent ('ac'), peak ('pk'), descent ('ds'), rise ('rs'), fall ('fl'), fall-off ('fo'), change ('ch'), and continuation rise ('CR'). (An '*N' in an 'accent' entry indicates the lack of a positive rise accent for that syllable.) The number of utterances used for each line of data is listed under 'N.' Each table is divided vertically by solid lines into sections for each speaker (whose
initials are listed under 'sp'). A short description of the characteristic which distinguishes one line from another is given at the left of each line. Each line is referred to in the text by the number at the left in the table (e.g., 'Table 1:1-2,', or simply '1:1-2,' refers to the first 2 lines in Table 1). The term 'case' refers to a set of data averaged across the speakers in a given table. 'Case' numbers are identical to the line numbers for speaker JA (whose data comes first in each table) (e.g., 'case #1 in Table 1', or simply '1, #1', would refer to data from 1:1,3,5, averaged). Unless otherwise specified, the discussion in Chapters 5-7 utilizes Fo data averaged across the speakers and across multiple utterances in a given group.

3.3) Range of Linguistic Phenomena Covered

A wide range of semantic and syntactic phenomena have been examined in the corpora of this study. Words from the following form-classes were used: noun, verb, adjective, adverb, pronoun, modal, auxiliary, quantifier, proposition, article, and interrogative word. Besides the basic subject-verb-object type of sentence, many other sentence constructions were used: co-ordination of NPs, verbs, adjectives, and clauses; embedded clauses (dependent and independent); parallel structures (e.g., comparisons); syntactic transformations (passive, clefting, pseudo-clefting, preposing, topicalization, dislocation); deletion of words (ellipsis, gapping); word repetition; anaphora; compounds; questions; PPs; contractions; quotations and parenthetical expressions; vocatives and apposition. Syntactic and semantic disambiguation were also explored. Within clauses, such complex
phrases were used as: non-co-ordinated NPs up to 6 words long; verb groups including 2 aux's, a modal, and a negative; and PP-sequences including 3 PPs.

This thesis does not cover Fo effects due to emotion or speaking in various 'tones of voice.' The examined speech was restricted to be from adult males, reading specific texts in a neutral manner in a quiet room. Spontaneous speech and conversations were not used.
4) **Summary of Fundamental Frequency Phenomena:**

4.1) Phonological Effects

In Chapters 5-7, the Fo phenomena found in the data are described in detail; however, since most Fo contours had effects from all 3 realms of semantics, syntax, and phonetics, and since the individual patterns cannot be described in isolation, the basic patterns are briefly described in this chapter, so as to enable thorough analyses of the individual Fo effects later.

The linguistic results of this thesis can be classified into 2 broad categories: semantic and syntactic Fo effects. While no clear distinction can be made between semantics and syntax generally, the Fo phenomena observed appear to fit well under two functional headings: those having the effect of semantically highlighting certain words in the utterance, and those helping to syntactically segment the utterance into smaller units. These **emphasize** and **delimit** functions appear to be the main linguistic objectives of all prosodic variation in speech. Thus, while the segmental features of speech (e.g., formants, spectral energy distribution, choice of voicing) convey the concepts of words to the listener, the variations of Fo and of the other suprasegmental correlates enable the listener to judge which of the words are important to the communication of the message and to combine the words into syntactic units so as to relate the word-concepts to his previous knowledge.
4.1.1) Semantic Highlighting

This phonological model for Fo follows Daneš' claim that intonation has 2 primary functions: to delimit or segment an utterance hierarchically into various syntactic sections by means of 'junctures,' and to signal the integration of the theme and the rheme in the utterance (1960:45). He claims that "the center of intonation (CI)" is always located on the rheme, and that the CI is normally placed at the end of the utterance (in accordance with a basic CD distribution), and if it is located elsewhere, it is in a marked or "deautomatized position," and that the rheme is then "emphasized for contrast" (46). It is Halliday's view that "in English information structure is expressed by intonation. Connected speech takes the form of an unbroken succession of distinctive pitch contours, or 'tone groups'"", each representing "one unit of information" (1967b:162-163), which "consists of an obligatory 'new' element . . . and an optional 'given' element; the main stress . . . marks the end of the 'new' element, . . . unless it is a response to a specific question, either asked or implied" (163).

The idea of CI or 'main stress' should be taken in the sense of sentence stress, and not as the lexical stress that each individual word marks one or two of its syllables as having. Though each word has a lexi-
cally-stressed syllable, only certain of the words in a given sentence receive sentence stress, and "the stress may change its neutral (normal) position according to the needs of the theme/ [rheme] organization of the utterance" (Daneš, 1960:47). This capability of English utterances to shift around the 'nucleus' to mark the rheme is discussed further in 5.3. For
example, in the sentence "The bears in the Arctic live on the land," the syllables "bears," "Arc-," "live," and "land" would be emphasized via Fo, and the major syntactic boundary between "Arctic" and "live" would also be marked in Fo. With normal CD, "land" would get the CI or 'main stress;' if another word received the CI, it would be a 'marked' situation.

When a given sentence occurs embedded within a paragraph or as the answer to a question, the sentences or question that precedes it forms for the listener an explicit framework of knowledge, with which he can evaluate the words in the given sentence. Words in that sentence which are repeat occurrences or 'anaphoric' referents of words in the prior context have already been established for the listener, and as a result, these words have higher expected probabilities for him than words not previously mentioned. The listener is more likely to anticipate hearing a word that has been previously mentioned than a word new to the discourse. Taking advantage of this situation, the speaker points out to the listener through prosodic means those words in his utterance which he least expects the listener to anticipate.

Among the prosodic gestures that a speaker can use for this word-emphasis function is Fo accenting. Judged against an inherent 'normal' pattern of gradually-falling Fo, deviations in the form of upward Fo movements and sharp Fo falls provide one means by which a speaker can call attention to those words he considers important in his utterance message. The more prominent the accent deviation in Fo, the more likely the speaker feels that
the word on which the accent deviation occurs is important or unexpected by
the listener. Thus the amount of Fo accent a word receives can be cor-
related with the degree of unpredictability of that word in context.

Since many words which are mentioned in the prior context of a question
of paragraph sentences are more easily predictable by the listener in an
ensuing sentence, those words have less need to be Fo highlighted and they
receive Fo accents lower than other, less predictable words in the sentence
and lower than those same words get in context-less situations.

4.1.2) Syntactic Grouping

Fo and intonation can be used by a speaker to delimit his utterances from
one another, to segment an utterance into phrasal units, and to integrate
words in the same syntactic unit together; in short, Fo breaks up an
utterance into smaller, organized portions to facilitate easier processing by
the listener. Intonation can be used: "to indicate the boundaries of
sentences, to differentiate sentence structures, . . . to connect the parts
of an utterance" (Adams, 1969:116). As Collier notes: "speakers are capable,
in the programming of intonation, of surveying entire sentence complexes;
they can "follow a strategy that is more sophisticated than the mere execu-
tion of a couple of prescribed major pitch movements to be applied with
stressed syllables" (1972:84). Specifically, syntactic structure can be
signalled by Fo.

"Sentence elements such as Subject, Predicate, Clause, Phrase, etc. are
determined by grammatical not phonological considerations, and no such element is always phonologically signalled," but often "pronunciation features... hold sequences together and therefore hint that they are playing a particular unitary grammatical role" (O'Connor, 1973:257). Lee notes that "we tend to perceive sentences in chunks or phrasal units," that "the grammatical structure of these phrases is important for the correct perception of the sentence," and that "the syntactic structure of the sentence is sufficient to specify much of the stress, pauses, and intonation of natural speech" (1969:280). Similarly, Stockwell claims that the "surface structure" of a sentence can predict "the range of 'optional phrasing' possibilities" in intonation (1971:25). Pilch notes: "given intonation patterns represent... particular grammatical phrase classes and constructions," but "a given phrase [may] occur with many different intonations," and "given intonation patterns" can be used with different "morphosyntactic structures" (1973:107).

Nooteeboom et al note that "delimiting perceptually important units of speech and preserving perceptual coherence within such units" is one "function of intonation," and in particular that intonation can "divide the incoming speech into perceptual wholes suitable for further processing" (1974:41). They speculate that intonation acts in a trading relation with "expectations generated on the basis of syntactic, phonological, semantic and extra-linguistic context" in providing "a sufficient number of segmentation cues" for an utterance (43).
Lea notes that many "linguists have claimed that intonation indicates the immediate constituent structure of English sentences (1973:18; e.g., Trager & Smith's finding "a one to one relation between boundaries between constituents and prosodic cues" (21)), and notes that Bierwisch's system is able "to generate an intonation contour (for a German sentence), if only the surface syntactic tree and related syntactic information is provided" (19). Gleason considers intonation and stress as "the dominant elements in the syntax-signaling system" (1961:169). Lieberman claims that "intonation has a central role in the transformational recognition routines that the listener must use for syntactic analysis . . . Intonation furnishes acoustic cues that tell the listener when he has a block of speech that constitutes a satisfactory input to his syntactic recognition routines:" Intonation helps by "grouping the words into different blocks which direct the listener's recognition routines toward one underlying phrase marker rather than another" (1967b:314-5).

The segmentation of a sentential utterance into smaller syntactic units is accomplished by sequences of Fo rises and falls. As a deviation from the normal gradually-falling Fo pattern, a sharp Fo rise or fall is often used to mark the start or end, respectively, of a syntactic unit. Thus a rise is often associated with the initiation of a phrase and a fall with its close. The final fall in an utterance, which notes the end of the last syntactic unit in the sentence, is usually distinguished from prior Fo falls by virtue of its falling to a value lower than the others. A major syntactic unit containing two or more accented words often forms a P-unit,
which is marked by a sharp initial rise and final fall, with Fo remaining high medially.

Non-final falls are often accompanied by 'continuation rises' (CRs) in Fo. The CR, typically a positive upturn in Fo on the last syllable of a syntactic unit, usually following a steep fall marking the close of the unit, is used to signal the listener that the utterance is not yet complete (Danes, 1960:44; Delattre et al, 1965; Coker & Umeda, 1971). The size of a CR is proportional to how major the syntactic boundary is, and to how important the ensuing words are to the utterance message. Major breaks and breaks preceding important information have bigger CRs.

4.2) Phonetic Effects

In a hierarchical analysis of Fo, the lowest level would involve phonetically-conditioned effects, modifications to the Fo contour due to aspects of the vocal tract anatomy, and to physiological requirements dictated by the phones of speech. Wang refers to this factor as being related to the "operating characteristics . . . of the speech mechanism" (1972:487), since the phonetic effects of Fo are not directly under speaker control. As such, the only linguistic information that Fo conveys phonetically relates to phonemic recognition.

4.2.1) Global Patterns

Several authors have commented on the overall shape of a statement Fo contour (denoted here as 'Tune A' as opposed to 'Tune B' of yes/no
questions (see 6.1)): on the first AS, Fo "rises rapidly to a peak at the beginning of a breath-group and then falls off" gradually in the body of the utterance, followed by a sharp Fo drop at the end of the utterance (Mattingly, 1968:170; also Koshikawa & Sugimoto, 1962:2; Delattre et al, 1965:151; Fujisaki & Sudo, 1971:134) (Fig. 4a). (Such a "breath group," "intonation group," or "sense group" pattern is often associated with "the meaning 'one unit of information'" (Cruttenden, 1970:184), or "a unit of speech that contains all the words necessary to transmit a single thought or a group of closely related thoughts" (Lieberman, 1967b:317).) This "archetypal normal breath-group" or Fo 'carrier' is a "prosodic pattern . . . used to delimit the boundaries of unemphatic, declarative sentences in normal speech" (1967a:27). The higher Fo at the start has been related to increased sub-glottal pressure at the onset of speech (Bolinger, 1964a:843).

In addition to the overall breath-group pattern, two other Fo phenomena may be considered as global phonetic effects: those of 'anticipation' and 'competition.' The speaker uses a wider Fo range in longer utterances than in shorter ones; he apparently 'anticipates' the greater amount of speech to be uttered in longer sentences and raises his initial Fo values to allow a wider Fo 'operating range.' The 'competition' effect can be described as one of 'conservation of accent,' in which the number of ASs in an utterance has an effect on the amount of Fo accent each gets: in utterances of the same length, the more ASs there are, the less Fo obtrusion each gets.
4.2.2) Reference or Declination Lines

It was noted above that pitch is relative, that changes in Fo, not absolute values, are important perceptually, probably due to the varying ranges and levels of Fo for different speakers. One model would be that Fo is judged relative to one or two 'reference' lines that can be superimposed upon the Fo contour. One can view a typical Tune A Fo contour as oscillating between these two lines (varying due to accenting and phonetic effects), or view the lines (upper and lower) as forming an 'envelope' in which Fo remains after the initial rise.

Since accent rises and falls occur superimposed on an overall falling Fo curve, successive upward accent obtrusions of similar size rise to successively decreasing peak values. Similarly, successive valleys in the Fo contour decrease with time in the utterance. The average 'tracks' that these peaks and valleys take are sometimes referred to as the upper and lower 'declination lines,' respectively (see 2.3). Peaks lying above the prototype upper declination line can be considered as having more accent than normal, and those below it as having less accent.

To a first approximation, these lines are formed by the successive Fo peaks (upper line) and valleys (lower line), starting with the first peak (which is usually the highest one) and following valley (also the highest), and continuing until the last peak. As such, these lines lie somewhere between straight and exponentially concave-upward, but are always converging and monotonically decreasing (although successive peaks and valleys
are not always so monotonically related), thus causing the 'envelope' to shrink with time. Since the 2 declination lines converge toward the end of an utterance, presumably equally-perceptible accent rises are smaller towards the end; (recall that the second of 2 equal-sized Fo obtrusions is more prominent (Bolinger, 1958a:130)); thus, for control, Fo accents in different utterances of this study were compared in similar sentential positions. These lines do not so much 'confine' Fo as they serve as guidelines, within which Fo stays most of the time. They may serve as 'reference' lines perceptually, so that a peak (or valley) which deviates from the upper (or lower) line would be perceived in terms of how far it varied from its 'normal' peak (or valley) value.

Related to the lower declination line is the concept of a "bottom ordinary range" (BOR) of Fo, which is a range of Fo immediately around the lower line, but is at most 20-30 Hz wide (for Peck's four male speakers, it averaged in the range 85-110 Hz (1969:47)). It is the range to which Fo usually falls at a roughly exponential rate after an accent peak (Öhman, 1967), and in which Fo remains until the next accent. Peck claims that this range is used for unemphatic monotonic speech, for stressless tails, . . . , and for parenthetical stretches of speech" (1969:36). Fo only goes below this BOR at the end of a Tune A contour, or in a rare "extra-low creaky-voice tone" (37), whereas excursions above it correspond to the ASs. Jassem noted that "a long string of low pitched syllables" will usually reside within such a "bottom pitch banâ" (1972:98).
4.2.3) Local Patterns

One local phonetic Fo phenomenon was that of 'separation' of accents, in which the amount of Fo obtrusion an AS is likely to receive is affected by nearby ASs. An AS 'well-separated' from other ASs by virtue of being adjacent (both before and after) to a number of USs tends to have a larger Fo accent than ASs closer to each other have.

Certain other local aspects of the Fo contour can be attributed to particular articulatory factors involved in uttering various phones. The most prominent of these involved the voiced-unvoiced distinction in certain consonants: the obstruent consonants (stops and fricatives) are distinguished not only by manner and place of articulation, but also by whether or not they have the attribute 'voicing.' The phonetic correlates of this voicing distinction (i.e. voiced versus unvoiced) do not involve a simple presence/absence of vocal cord vibration, but rather concern a complex of parameters, including: the voice-onset time in stops (if the vocal cords start vibrating before the release of the stop, or immediately thereafter, the consonant is perceived as voiced; if the vibration starts about 50 msec after the burst, the stop is usually perceived as unvoiced), the degree of 'force' or 'tenseness' used in articulating the consonant, and the shape of the Fo contour at the consonant-vowel transition.

In stressed vowels, there is a systematic relationship between the tongue height of a vowel and its Fo, viz., "higher vowels have higher Fo" (Lehiste, 1970:68). Lehiste's data for one speaker show a 23 Hz range of
Fo variation due to tongue height (160 Hz for /aU/ to 183 Hz for /i/) (69), and, as a result, Fo undergoes larger accent rises with high than low vowels (Lehiste & Peterson, 1961:424; also Lea, 1973:61). Lea found that "tongue height in vowel articulation does affect the magnitude of Fo rises and falls ... after medial consonants, but not always consistently" (51). He notes that "the preceding consonant may have even more effect" on vowel Fo than tongue height has (46). Ainsworth notes that Fo may be used in phonemic recognition of the vowels: "it is possible that some listeners employ Fo to compensate for the differences in vowels produced by men, women, and children" (1974:126; also 1971:1323).

The phonemic effects can be considered the most local Fo phenomena because they vary with the individual sounds that make up each syllable, and such alterations in Fo rarely extend their domain more than a syllable distant. This thesis has not addressed the phenomenon of high vs. low vowels, since the interest here lies in more general trends in Fo and since Fo changes, rather than absolute levels, seem to be the most important parameters in Fo description. In synthesis-by-rule schemes, however, it is probably desirable to differentiate the Fo level in accented vowels by a few Hz depending on tongue height.

Regarding the other phonemic Fo effect of consonant voicing, direct evidence of the voicing effect on Fo has been found in the corpora; while ASs starting with voiced consonants or vowels (denoted as 'voiced' syllables) had little prior Fo jump and mostly Fo rise during the vowel, ASs with
unvoiced initial consonants (denoted as 'unvoiced' syllables) had Fo jump up during the voiceless section of speech and little, if any, Fo rise during the vowel (Fig. 5). Voicing factors had Fo effects after the accent rise as well: in polysyllabic words with accent on a non-final syllable, the voicing of the consonants between the accented vowel and the next vowel had a significant effect on the manner of Fo fall after the accent rise. When the intervening consonants were all voiced, Fo dropped little (at most 10-15 Hz) before the unaccented vowel, whereas when some of the intervening consonants were unvoiced, a large Fo drop often occurred between the accented and unaccented vowels, taking Fo down close to the BOR rapidly.

4.3) Hierarchical Analysis of Fo Patterns

To understand how an Fo contour conveys linguistic information, it is useful to analyze the Fo pattern hierarchically. Many factors affect various aspects of the Fo contour: Phonological (syntax and semantics), phonetic (physiological), phonemic (minimal disambiguation), and emotional (attitudinal) factors all play specific roles in altering the Fo pattern. A typical Fo contour can be viewed as the composite result of a set of hierarchical patterns (associated with sentence, phrase, word, and phoneme), with the Fo effects of each successive (more local) pattern being superimposed upon the previous higher (more global) Fo phenomenon (Fig. 4).

The sentential or highest hierarchical level encompasses the Fo pattern on the sentential utterance as a whole. In most utterances other than yes-no questions, Fo starts on a medium-low level, rises rapidly on the first AS,
and then gradually falls to a low level at the end of the utterance (Tune A). The phrase level of Fo utilizes Fo rises to initiate syntactic phrases and falls to close them. In addition, non-final phrases are often marked with CRs.

At the word level occur variations in the contour due to the accenting of certain words within the utterance. This 'accent' is usually manifested by an upward Fo obtrusion above the generally-falling Fo pattern, but also occurs in the form of a sharp Fo fall preceded by rising or relatively level Fo (Bolinger, 1958:111-116; Denes & Milton-Williams, 1962; Lehiste & Peterson, 1961:419; Morton & Jassem, 1965; Atkinson, 1973:233). In either case, the prominent factor of Fo accent is that it marks the syllable on which the Fo rise or fall is initiated as being 'accented' in comparison to other syllables in the sentence. A word is considered to be accented if its 'lexically-stressed' syllable receives Fo accent. 'Phrase-level' stress rules like the NSR predict accent patterns at this word level.

Effects due to phonetic differences introduce the local Fo perturbations assigned to the phonemic (lowest) level in the Fo hierarchy. Of main interest here are the Fo deviations caused by consonants. Unvoiced consonants cause voicing to be interrupted (and hence Fo to cease), whereas voiced consonants (especially voiced obstruents and liquids) lead to dips in Fo. In addition, the Fo pattern on an AS differs depending on the characteristic of voicing of the initial consonant in the syllable: after a voiced consonant, Fo continues rising to a peak in the vowel before falling,
whereas after an unvoiced consonant, Fo starts at a higher level and usually falls immediately (Peterson & Lehiste, 1960; Lehiste & Peterson, 1961; Haggard et al, 1970; Fujimura, 1971).

4.4) Units of Fo Analysis

4.4.1) Sub-contours

As described above, certain Fo patterns can be associated with phonological factors and others with phonetic requirements of the spoken sentence. The semantic patterns of Fo accenting may be viewed as being superimposed on a global Fo shape; patterns each encompassing an Fo rise above the global 'carrier' and an ensuing Fo fall to the carrier have been interpreted here as constituting Fo 'sub-contours' (SCs). Each utterance-contour consists of one or more successive SCs, superimposed on a gradually-declining Fo carrier. Each SC begins on an AS, with the rise in Fo on that syllable lending it 'prominence' or accent.

This SC pattern on an AS and ensuing USs has a shape similar to the global carrier, but on a smaller scale (Fig. 6a): viz., Fo rises to a peak on the AS, rounds off, falls on the next US, and continues falling on later USs, but at a decreasing rate, so that the fall has an exponential shape to it, with Fo eventually bottoming out at the lower 'declination line,' if enough USs follow (before the next AS, which starts a new SC). Not every AS initiates this SC pattern (denoted "the terraced rice paddies of Burma" by Ohala (1970:96)), but, for deliberate speech, this tends to be a common pattern; certain syntactic structures and more rapid speech lead to Fo
falls being used to mark accents, rather than having a separate Fo rise for each AS. For example, Slis' synthesis algorithm assigns SC-type Fo rise-falls to all but the last two ASs in an utterance, which in turn receive a rise on the first and a fall on the second (1971:29).

Not all of the archetypal SC (a rise-fall-flat pattern) is fully realized each time an Fo accent occurs. If the AS starts with an unvoiced consonant, the initial rise is very often 'omitted' (in the sense that that part of the Fo contour 'occurs' in the unvoiced section of speech), so that what remains is a short, relatively flat Fo section, followed by a somewhat 'exponential' (concave-upward) fall to a relatively flat Fo at a low level (the BOR, described above). Often, even the initial flat portion is omitted as well after an unvoiced consonant, so that Fo immediately falls with the onset of voicing.

The SC may be prematurely terminated as well; since SCs begin on ASs, the presence of such a syllable in the flow of speech causes previous SC to end and a new one to begin. The prior SC may terminate at any point after Fo has begun to fall from the peak in the SC obtrusion. In a similar observation, Erikson notes (for Swedish) that "a decrease in vowel duration . . . resulted in a final truncation" in the Fo pattern, rather than "a reorganization of the Fo pattern," and suggests "that Fo is coupled to the vowel onset" (1973:59; also Collier, 1970:83).

Describing the Fo contour in terms of SCs each consisting of a modified
prototype obtrusion should capture a generalization in the movements of Fo in an utterance. If a speaker's use of Fo can be reduced to the manipulation of a few parameters within the context of a consistent Fo prototype, the remaining task is to determine the sizes of these crucial parameters and how they relate to the syntax and semantics of the sentence. While each SC is modelled on the same prototype, the speaker is free to vary the amplitude of the excursion (i.e., the amount Fo rises to the peak, and the Fo value at that peak) as well as the timing of the obtrusion.

4.4.2) Variations

One of the basic duties of Fo is to mark which syllables of the sentence are accented, in order to call attention to them as the focal points in the communication of the message. While the primary way to implement accent is to cause Fo to jump up and/or rise on the AS's vowel, there appear to be other ways to call attention to an AS. Assuming that the SC constitutes the basic Fo pattern, any significant variation is likely to call attention to the syllable on which the variation occurs. Specifically, 3 such types of major variations to the basic SC were:

1) Rather than having Fo rise on one syllable, and then fall thereafter, Fo rose in a continuous movement over two syllables, thus accenting both of them. These 'double rises' involved two different words, usually occurred in auxiliary-verb phrases, and had most of the Fo rise on the second syllable (Fig. 7).

2) Rather than having Fo fall directly toward the BOR in a rapid, exponential-type fall, Fo was retained at an intermediate level, with con-
siderably less Fo fall on one syllable after the main AS (Fig. 6b). This form of 'secondary accent' (as well as the type of accent in #1 above) occurred most frequently on 'weak' potentially-acceptable (PA) syllables (see 5.1.2), when such syllables occurred near stronger syllables. Rather than fully articulate an independent Fo rise+fall for each, the speaker economically chose to give these 'secondarily-important' words 'half an accent' by altering the basic SC movement of the prior AS enough to call attention to the current syllable as well.

3) Instead of having Fo fall directly to the BOR after the AS, the speaker had an option to retain his Fo at a high level, with very-slowly-falling Fo over a number of USs in a syntactic unit, before a rapid Fo fall-off on the last AS of the unit (Fig. 6c). This rise+relatively-level+fall pattern is denoted here as a 'phonological unit' or 'P-unit,' and its use appears restricted to coherent syntactic phrases of the type: NP, PP, or VP. In this situation, the rapid Fo rise on the first AS of the P-unit begins the SC and marks its first accent, and the rapid Fo fall-on the later AS marks the second accent in comparison with the slowly-falling Fo of the intervening USs.

A measure of accent should be used that quantifies well the amount of 'deviation' from the 'normal' Fo falling pattern. Since these notions are not well established, the parameters of accent in a given upward obstruction were chosen to be simply the amount Fo rises, the steepness of the rise, and the peak value attained. In the cases of steep and slight Fo falls, the amount and rate of the fall were chosen as accent parameters. In these lat-
ter cases, the prior Fo shape is especially important: steep falls mark accent only if occupying just one syllable's duration, preceded by rising or relatively level Fo, and followed by low, more level Fo; and slight falls mark secondary accent only if adjacent syllables with falling Fo have steeper, more extensive falls; if a syllable occurs between two Fo rises, it is judged to have secondary accent if the amount of Fo fall on it is slight compared to that of an US in a comparable situation in another utterance.

In addition, the amount Fo drops between one vowel and the vowel in the next syllable appears related to the amount of accent each syllable gets: an Fo drop after a syllable's vowel tends to enhance the deviation or prominence of that syllable (Bolinger, 1958a:129); whereas lack of a large drop tends to keep Fo above the normal falling pattern, thus allowing the ensuing syllable's Fo to also be above the normal line (giving that syllable more accent). As such, a third parameter in falling accents should be the amount of prior descent (of which less would lead to more accent); by the same token, the amount of Fo descent after the Fo peak in an accented vowel should also be considered as contributing to its accent.

4.5) Statistical Analysis

The nature of the free intra-speaker variation present in Fo patterns was examined in set A; speaker KS recorded 229 sentences, all of the form "Say X instead," where X represented 229 different words: 17 monosyllabic words, and 212 bisyllabic words (197 with the initial syllable stressed).
Thus the syntax and sentence length was fixed, and the X word was always in second position. Fig. 8 shows the distributions for Fo values at 3 selected points in the utterances: at the end of "Say," at the peak in X, and at the peak in "instead." The values on the fixed words ("Say," "instead") showed less variation (ranges of 18 Hz, standard deviations (SDs) of 4.0 Hz) than those of the varying word X (range of 32, SD of 5.5).

4.5.1) Rise Accents

In these short utterances, all 3 words had some degree of accent. Fig. 9 shows the distributions of Fo rise accents for X and "instead." "Instead" received accent in the form of a jump between the nuclei of its 2 syllables; it averaged +17.3 (SD of 4.1). The rise accent of X was comparable when its second syllable was accented (+16.1, SD of 5.1), but was smaller otherwise. When X was accented on the first of 2 syllables, its accent was +6.9 (3.6 SD) if the syllable began with a voiced phone, and only +3.2 (4.0 SD) if unvoiced. For monosyllabic X, the accents were even less: if a voiced start, +4.5 (5.1 SD), and if unvoiced, +1.1 (1.7 SD).

Thus the phonetic effect of consonant voicing led to about +3.5 Hz more accent following unvoiced than voiced consonants. However, the larger differences can be attributed to separation. The AS of "instead" was always preceded by its US and received a moderate accent; similarly, when X was accented on its second syllable, its AS was preceded and followed by an US, and received a moderate accent. However, the monosyllabic X was immediately preceded by the accented "Say," and had only a small rise accent.
The other bisyllabic X also had its AS bordering "Say" and had only small rise accent; but, due to the extra US after its AS, it had more accent than the monosyllabic X.

Using a +10 Hz rise accent as a somewhat-arbitrary threshold to divide ASs from USs, "instead" and X with its second syllable accented would pass, but the other X would fail (especially considering the large SDs compared to the sizes of the accents in the latter cases). Thus one must look to the degree of fall accent on X to find why these latter X were accented.

4.5.2) Descents

Fig. 10 shows the amounts of Fo descent on X: averaging -26.0 for monosyllabic X, -29.6 for bisyllabic X accented on the second syllable, and -20.7 for bisyllabic X accented on the first. Again, voicing made a difference, with 5.8 more descent from an unvoiced than a voiced peak. The SDs here ranged from 3.6 to 7.7 Hz. These SDs indicate a relatively wide range of possible Fo descents, but the average descent was big enough so that, coupled with a small accent rise, X should be perceived as stressed.

In the bisyllabic X with its second syllable unaccented, Fo continued to fall in that US (Fig. 11), averaging -9.9 (5.3 SD). The total Fo fall-off during X was much greater than the ensuing fall-off on the US of "instead" (Fig. 12), which averaged -1.9 (2.9 SD). Similarly, when "instead" immediately followed an AS, the fall on "in-" was a small -3.8 (2.9 SD). Thus the large fall-off on the AS of X (plus its rise accent) marks it as accented
when compared to the small Fo change on an US like "in-." (The -8.9 descent on the initial US of X (Fig. 13) does not mark it as accented, because it was preceded by a -9.3 drop and because the descent was too small.)

Of the bisyllabic X stressed on the first syllable, 102 consisted of 2 separate words and might be called 'compounds' (e.g., "timepiece," "hemline"), while the other 95 had no such interpretation (e.g., "seismic," "seedling"). This distinction had little effect on the Fo pattern in these controlled sentences other than to alter the distribution of Fo fall-off on X. Compared to the other X, the 'compound' X averaged 2.0 Hz less descent and 2.3 Hz more fall on the second syllable. This shift of fall-off to the second syllable gives it more relative prominence, and can be related to a 'double-stress' interpretation of such 'compound' X. While many of these formed actual compounds (see 5.1.3), with definite stress on the first syllable, others tend to have equal stress on both syllables (Goldstein, 1976). There were more of the latter than the former in set A, which led to smaller descents on the 'compound' X here.

4.5.3) Summary

The Fo analysis of the simple construct "Say X instead" involved factors such as the number of syllables in X, the location of lexical stress in X, the voicing of the AS, and the morphemic construction of X. The chosen parameters of rise accent and descent have been shown to be consistent for an analysis of the words in these utterances. The ASs had larger rise accents and descents than the USs. For small rise accents, the SDs were on the order
of the accents themselves, but for larger accents and descents, the SDs were only 15-35% of the accent sizes.

However, the SDs were large enough to eliminate any possibility of quantum levels of accent. Accent is clearly a continuous phenomenon, with syllables ranging from heavily de-accented to heavily accented. Attempts to quantize stress into several levels (Pike, 1945) have failed in perceptual tests (Lieberman, 1965). Even the borderline between ASs and USs is vague. One can only accurately discuss amounts of accent and show that certain syllables have more accent than others. This lack of simple accent categories has forced the analysis of this thesis to be a descriptive one, in which linguistic and phonetic phenomena are related to degrees of difference in accent, with 'stronger' phenomena having greater differences in accent.
5) **Semantic Effects:**

5.1) Lexical Phenomena

5.1.1) Content-function Distinction

A correlation can be made between words from certain form-classes and the amount of accent each member word receives in a typical utterance. Words conveying the most information to the listener tend to have the largest accents. While the 'amount of information' a word represents in a given utterance depends substantially upon context, a first approximation can be made based on the form-class to which a word belongs. Words from most 'closed' classes (i.e., form-classes with small and relatively fixed lists of members) are non-lexical or 'function' words and represent inherently 'old' information, with a tendency toward lesser accents. Words from the 'open' classes (i.e., classes whose members are changing with time and usage) are called lexical or 'content' words and provide inherently 'new' information with concomitant bigger accents. With some exceptions, such as contrastive accents and 'modality operators' (see 5.1.2), only content words are eligible for primary accenting in utterances.

In this "content-function distinction," "content words convey substantial meaning in the sentence," while "function words, usually monosyllabic, serve mainly to establish grammatical relationships" (Flanagan et al., 1970:39). The **function** words include: articles, prepositions, personal pronouns, possessive adjectives, relative pronouns, common conjunctions, 'one' used as a noun substitute, auxiliary verbs (denoted as "aux's"), reflexive pronouns, and monosyllabic adverbs of degree; whereas the **content**
words consist of: nouns, most verbs, adjectives, adverbs, demonstratives, interrogatives, interjections, indefinite pronouns (Lightfoot, 1970:51; Pike, 1945:28). Flanagan et al also postulate a third category: "intermediate" words, such as "polysyllabic less-frequent prepositions and conjunctions, and frequently used verbs," as well as "some pronouns, adverbs, and adjectives" (1970:39). For synthesis purposes, they assign "no stress," "weak stress," and "primary stress" to the function, intermediate, and content words, respectively. Coker et al used 9 levels of stress (which actually is "a continuous rather than quantized variable in natural speech" (1973:296)) to describe the new/old continuum: new nouns; function words used as complements; repeated nouns, new infrequent verbs, adjectives, adverbs; repeated infrequent verbs; interrogatives, quantitatives; frequent verbs; less frequent function words; ordinary function words; function words with schwa. Their "system assigns a pitch target value to every phoneme," and passes these values through a filter "slow enough that pitch does not quite reach the target." The target values follow the "'content/ function' distinction" of the list given above, with higher Fo values for the content words and lower ones for the function words (a range of 100-160 Hz was used) (296). "Words that are high on the list convey most of the meaning of the sentence," since they are "the least reduced;" "the higher a word is on the scale, the less predictable it is from context" (Coker & Umeda, 1971:139). Olive claims that "function words are very short and their Fo contour would not be very critical" for synthesis purposes (1975:479).

"Words used very frequently, in general or in a particular discourse, are
highly predictable, and usually take a lower value in the promotion (stress) scale;" "the unconditional (i.e., language-wide) probability of occurrence of a word is another measure of its promotion value" (Umeda, 1975: 14). Word classes with more members have a lower a priori probability of occurrence for each member word in a given context, and thus such word classes are higher on the stress scale. This is likely one explanation for nouns and adverbs receiving more accent than verbs (Lightfoot, 1970:52) (see 5.1.2). For instance, Schmerling claims that "predicates ... receive lower stress than their arguments" (1974:614; Coker & Umeda, 1971: 138); while Firbas says that "the object is usually relatively more important than the verb" and "will carry a higher amount of CF than the finite verb if it conveys new, unknown information, i.e., if it is contextually independent" (1968:44; 1969:49). This effect is interpreted here in terms of a correlation between the size of an open word-class and the amount of Fo accent a member word receives; i.e., the more possible words that can occur in a given sentence position, the more likely a large Fo accent will occur on a word in that location.

5.1.2) Modality Operators

In most utterances, there are one or more lexical words most important to the transferal of the sentential message to the listener. These words are often syntactically-optional, in the sense that many grammatical sentences occur without them. These words may be considered the sentence 'foci,' and tend to receive heavier accents than the other words in the sentence. Unfortunately, deciding which words in a sentence are the foci
is not always straightforward, since, in general, any word in a sentence can be singled out for CS, and have 'focus.'

Certain word classes are more 'inherently contrastive' (IC) than others, in that words from these classes are more likely to be new information or foci in sentences than are those in other word classes. By their syntactic membership in one of the IC word classes, these words have a clear tendency to be among the foci of a sentence. Word classes such as the function words are clearly non-contrastive and have no Fo accent. Classes such as nouns and finite verbs are not considered IC; however, since they are content words, their lexically-stressed syllables are PA syllables and eligible for accent.

The IC words are the syntactically-optional in the sentence. If one considers the 'basic' sentence in English to consist of subject - predicate - object, it has the essential format of noun - finite verb - noun (with perhaps some function words for grammatical purposes); i.e., the basic nucleus or proposition consists of nouns and verbs (as the lexical words). Such other lexical word classes as adverbs, modal aux's, negatives, and quantifiers (the modality operators (MOs)) are not required elements of a sentence. When they occur, they have specific and very useful functions, basically those of modifying and delimiting the 'nucleus idea' or propositional content of the sentence, as defined by the framework sentence of nouns and verbs. The MOs implement the interpersonal role of language.
Hence, the English sentence can be divided into a nucleus (consisting of nouns and verbs) and a set of operators (the MOs) which modifies the nucleus (Fig. 1)(Seuren, 1969). The nucleus often constitutes the 'theme,' or the old information, while the modifying operators specify new information. Thus, the MOs, inherently related to being the new information, are more likely than non-MO words to have Fo accent. The Fo obtrusions on MO words are larger and more 'resilient' (in the sense that they are less susceptible to phonetic accent-reduction processes) than those of other words.

Specifically, the speaker gives heavier Fo accents to the MOs in a sentence than to words in the proposition, because the former indicate the speaker's commitment to the truth value of the latter; he highlights the words he considers important to assist the listener in understanding the message. The content words of the nucleus are more likely to be old, predictable information than the MOs; when the MOs occur in a sentence, they usually form the major information points of the sentence, whereas the content words of the nucleus provide the main information when no MOs are present.

5.1.2.1) Simple Verb-groups

5.1.2.1.1) No Auxiliary-verb Group

The first group of sentences (Tables 1-4) was composed using the basic sentence "Joe studied his books" and inserting various aux's, negatives, and contractions into the verb group, keeping the subject and object the same. Variations on the basic sentence (Tables 5-12) included: using a
quantified subject, using questions (both of the yes/no-and the Wh-type), inserting one of 7 sentential adverbs (and an optional "not"), replacing the subject by "Joseph" or "Josephine," and replacing the main verb by other verbs.

The sentences for most of 5.1.2 were from set D (with speakers JA, KS, and ML). Due to the frequent inconsistent readings of ML, the data for his speech have not been included in the averages in the ensuing discussion; however, his patterns are displayed in each of the tables below, and, where relevant, his curves are referred to. Unfortunately, ML's reading style was less disciplined than those of the other speakers, and he often used different intonations for variety, rather than speaking each sentence as in the same context-free environment.

The peak pattern for the basic sentence "Joe studied his books" (Table 1, #1) was 143-135 (Figs. 14-15). (Note: in this section, the data for "... his books" have been deleted from the tables and figures, because their Fo patterns varied little over the various contexts). For "Joe's studied ..." and "Joe'll study ..." (1, #2), the pattern was 147-133. The addition of a contracted aux to the verb group appeared to have the small effect of increasing the peak differential between the subject and verb by 6 Hz; this is likely due to the greater informational load carried by the initial AS: in #2, it conveyed not only the subject "Joe" but also the aux in contracted form. Being adjacent to the initial AS, "stud-" (the lexically-stressed syllable of the verb) had little accent (only +2 rise accent and -11 fall accent) in both cases, due to the lack of separation in time between the PA
syllables of the two content words ("Joe" and "studied").

5.1.2.1.2) One-syllable auxiliary-verb group

In utterances with a one-word aux-verb group (Table 2; Figs. 16-18), the basic pattern had accent on "Joe" and "studied," with an unaccented aux intervening (#1). The peak pattern was 150-(128)-131 (where the peak in parentheses represents that on the unaccented aux). In contrast to this pattern for a 'normal' aux were the peak patterns for the same sentence with a 'dummy' aux, a 'class A' modal (henceforth referred to simply as 'modal' (see below)), and a negative contraction (i.e., "can't," "won't"): 143-144-(117), 145-136-(115), and 146-136-(121), in #2-4, respectively. In these latter cases, the parenthesized peak is that on the verb, which was de-accented. At its highest (#4), the peak on "stud-" was -10 lower than in #1, and, instead of the +16 accent rise in #1, there was an average descent of -21 from the peak on the preceding word in #2-4.

Clearly the major Fo difference between #1 and #2-4 was the increased accent on the word between "Joe" and "studied." Where the aux was unaccented in #1 (it had a -23 prior descent), the replacement words in #2-4 averaged a +11 accent (to a peak +10 higher than in #1). Besides the de-accenting of "studied," the accenting of the dummy, modal, or negative contraction in post-subject position led to a decrease in accent on the subject (-5 lower peak), due to a separation effect. Among the words in second accent position, the dummy had the strongest relative accent, with a peak +1 higher than that on the preceding "Joe." Of the other 2, both with peaks -9 lower than on
"Joe," the modal had a relatively stronger accent than the contraction, since it had +10 more accent and reduced the ensuing verb peak -6 further than the contraction did.

Thus, among the single words which can occupy the aux-verb group, an ordering of dummy, modal, negative contraction, and 'normal' aux can be postulated for decreasing amounts of accent. Each of the first 3 word types represents a MO, while the aux does not. The dummies received heavy accent because they are 'unnecessary' to the basic message of the utterance (e.g., "Joe did study" = "Joe studied"); hence the use of a dummy in a situation not requiring it as a placeholder (as it is used with a negative or in a question) coincides with implicit emphasis of affirmation (see 2.4.1), and as such, the speaker uses accent to call attention to the dummy.

'Class A' modals (including "might," "must," "may") often receive accent, while 'class B' modals (including "can," "will," "would") usually do not and the aux's (forms of "have," "be," and "do," in their usual usage) always do not (except in cases of contrastive accent), because the 'A' modals express part of the speaker's attitude toward the proposition, in much the same way that dummies do in positive sentences (as above), while 'B' modals and aux's express part of the proposition. However, since the distinction is not as clear as in the dummy case, the modal accent was less than that of the dummy, and indeed there were several cases where the speaker did not accent 'A' modals (these were included with the aux's in 2, #1). The negative contraction received the least accent among these MOs because, while expressing
the important factor of negation, contractions by their nature represent an economy in the message. If a negative is unexpected by the listener, the speaker usually uses the full form of "not" with heavy accent (see below); but when negation may be more expected, a contraction is often used and the Fo accent is less needed.

5.1.2.1.1) Two-syllable auxiliary-verb group

Table 3 and Figs. 19-24 concern utterances which had 2 syllables between the subject and verb. The basic 2-aux case ("Joe has been studying . . .") had a peak pattern of 152-130. Quite similar to 2, #1, both aux's were unaccented here (-15 and -23 prior descents); "stud-" had +8 more accent here than in the 1-aux case, due to the greater separation of the extra unaccented aux. When the second aux was replaced by "not" (#2), the peaks on "Joe" and "stud-" decreased by -6 and -8, respectively; "not" received accent (+26, to a 137 peak), whereas the verb was de-accented (having a -17 descent, vs. a +21 rise accent in #1): the peak pattern of 146-137-122 exemplified the heavy accent on "not," with its small -9 drop-off between the peaks of "Joe" and "not."

When the first aux was replaced by a modal (#3), the accent pattern varied slightly: the accent on "not" was +20 (-6 less than in #2). In addition, the descent on the modal was only -10, compared to -23 and -16 on the respective aux's of #1-2. This lesser decrease, as well as the decreased accent on the ensuing "not," can be considered a form of 'secondary accent' on the modal, in which the modal exhibits its importance (secondary, in com-
parison with the negative) by a lesser falling rate and by a decreased accent on the adjacent negative.

When a bisyllabic negative contraction occurred between "Joe" and "stud-" (#4-5), the accent pattern was about midway between those of the 2-aux case and of the "not" cases. In apparent free variation, the speakers placed primary accent on the contraction in 14 examples (#4) and only secondary accent on it in the other 9 examples (#5). In each case, the ensuing verb was reduced in accent compared with #1 (having a peak −4 lower); but in #5 (where the contraction had less accent) the ensuing verb had +4 more accent than in #4, due to a separation effect. When primarily accented, the contraction had a peak +8 higher than that on "not" above, but this should be due to the earlier utterance position of the contraction; in terms of rise accent, the contraction's Fo rose +14 (vs. +26 on the "not"). When secondarily accented, the contraction had a descent of only −11 on its first syllable, compared to a −23 descent on the first aux of #1.

A similar type of free variation occurred in #6-7, where a modal replaced the first of the 2 aux's in case #1. Speaker JA accented the modal in 12 of 15 examples (#7), while giving it only secondary accent in the other 3 examples (#6). KS, on the other hand, chose to give it only secondary accent in all of his examples. In the latter case, the modal had a small −11 descent (the same as in the negative contraction of #5), but the accent-reducing effect on the subject and verb was nil, with the verb getting a full +24 accent here. Even when JA gave the modal primary accent (+28
accent, to a peak +24 higher than on the preceding "Joe"), the verb re-
ceived a +15 accent, due to the 'buffer' separation of the unaccented aux.

5.1.2.1.4) Three-and four-syllable auxiliary-verb group

Table 4 and Figs. 25–28 involve sentences with 3- and 4-syllable aux-
verb groups. The peak patterns for #1 (aux+"not"+aux) and #2 (modal+"not"+ aux) were similar, averaging 144–146–119. Again, "not" had heavy accent
(+29 accent, to a peak +2 higher than the initial peak in the utterance).
Furthermore, the accent on the ensuing verb was reduced (only a +9 accent, to
a relatively low peak), even though an unaccented aux separated the verb from
"not." (This extra US apparently helped to raise the accent on "not,"
relative to 3, #2-3: the increased separation from the verb enabled a +6
accent increase and a +8 higher peak.) Unlike 3, #2-3 however, whether the
word preceding the negative was an aux or a modal made little difference in
the accent pattern. JA distinguished the modal from the aux by having a
small -5 descent on the modal vs. a -22 descent on the aux; but KS's
patterns were the same. Thus it appears that, in cases where the modal is
not primarily accented, it cannot be consistently distinguished from an
aux in KS's patterns.

Actually, KS's lack of differentiation of modal and aux was not surprising,
since he did not give the modal primary accent in #3 either, where the modal
was followed by 2 unaccented aux's. JA, on the other hand, gave the modal
here a +20 accent, to a peak +15 higher than that on the preceding "Joe."
For both speakers, the ensuing aux's were unaccented, leading to a normally
accented verb (a +22 accent to a peak +8 higher than in #1-2, which had the accented "not" closer to the verb).

When the aux-verb group consisted of a bisyllabic negative contraction followed by an aux (#4), the contraction was accented (+12 accent, to a peak only -4 less than that on the prior "Joe"). This accent on the contraction was less strong than that on "not" above; adjacent to "Joe," it only reduced "Joe"'s accent by -2 more than "not" did with an intervening US. Yet it was stronger than the modal of #3 in that the verb's accent was reduced further (-5 less accent, -9 lower peak) in #4. Actually, the insertion of an extra unaccented aux before the verb in #3-4 had little Fo effect (cf. 3, #4-7), with the exception of guaranteeing a primary accent on these MOs (except on the modal for KS). Increasing the separation between two content words from 1 to 2 USs apparently did not result in major Fo variations here. Indeed, when in #5 an extra aux was added to the aux-verb group of #2 (modal+"not"+aux+aux), JA's Fo patterns were virtually identical, the only difference being that the Fo fall occupying 1 aux in #2 was spread over 2 aux's in #5.

In 5 of the 15 examples with modal+"not"+aux as the aux-verb group, JA placed accent on the modal (#6), instead of on the negative (#2). This apparently free variant had a very large accent on the modal (+29, to a peak +29 higher than that on the preceding "Joe"), while the ensuing "not" was completely de-accented, with a -29 prior descent. When "not" had received the accent, the modal at least got a secondary accent. Thus, this
'accent shift' option is more than just a choice of which of 2 consecutive MOs to accent. It appears to be a situation of 'contrastive accent,' in which the usual, 'unmarked' case of accent on the 'stronger' negative was altered to the 'marked' case of accent on the modal. As in other contrastive accent cases, nearby words ("Joe" and "not") were considerably reduced in accent.

5.1.2.2) Quantifiers

5.1.2.2.1) Quantified subjects

When a quantified subject was substituted for "Joe" in Table 5 and Figs. 29-31, the major Fo difference was that of increased accent on the subject. The basic sentence (#1) here was "Q boys might study their books," where Q was one of 6 different quantifiers ("all the," "both," "many," "some," "these," "no"). The peak pattern of 160-116-119 exemplified the heavy relative accent on the quantifier: the initial peak was +15 higher than in the corresponding version with "Joe" as subject (2, #3), and in that case the peak on the ensuing modal was only -9 less than that on "Joe," whereas here the peak differential was -44. As above, KS showed only slight accent on the modal, thus allowing a +14 accent on the ensuing verb. JA, on the other hand, gave the modal the same +17 accent here as in the earlier case with "Joe," and similarly, the verb was not accented here.

The peak pattern for #2 (Q+"boys might have") was 164-120-118; thus the added aux apparently raised the first 2 peaks by +4 Hz. It also allowed a +19 accent on the verb, due to the increased separation between the modal
and the verb. When "not" was added as well, JA accented it in 10 of the 14 examples, as did KS in all of his examples (#3). The peak pattern of 166-118-138-111 exhibited less accent on the modal and verb (-4 less accent, -5 lower peaks) than in #2, as well as a stronger accent (+22, 138 peak) on the negative, than the modal had in any of #1-3. Again however, the accent on "not" was less (-7 less) after the quantified subject than after "Joe". Thus the presence of the quantified subject appeared to have the effect of reducing Fo levels and the range of Fo variation in ensuing ASs.

As in 4, #6, JA, unlike the other speakers, chose to accent the modal instead of the negative in 4 of the 14 examples (#4 here). As above, the modal accent was large (+27, to a peak +1 greater than on the prior quantifier - cf. the +19 accent on the modal in #2, to a peak -35 lower than on the quantifier), the ensuing negative was de-accented (by a -23 prior descent), and the preceding subject was also reduced in accent (-29 lower peak than in #2-3). In comparison, the negative of #3 had only a +17 accent and allowed a +9 accent on the prior modal, rather than fully de-accenting it.

Regarding the quantified subjects themselves, the average pattern of #1-3 consisted of a 163 peak (which was higher than in any of the initial peaks in Tables 1-4, which had "Joe" as subject), followed by a -29 prior descent on "boys" and a -24 prior descent on the modal. This sharp rise and fall was typical of a syntactic unit with 2 content words, with the Fo pattern forming a P-unit. (KS went so far as to end the relatively short subject with a +5 CR). That the quantifier was more important than the
noun "boys" was indicated by the large prior descent on "boys." While the main speakers (JA and KS) followed this pattern consistently, ML accented "boys" at the expense of the preceding quantifier in 4 of his 17 examples (5:19-20). That this was a 'marked' situation for his speech was indicated by its use in only 24% of these utterances, and by the +10 higher peak on "boys" when primarily accented compared to that on the quantifier when it received the accent instead (5:16-18).

For comparison with the quantified subjects, the Fo effects of replacing "Joe" as subject with "Joseph" and "Josephine" are shown in Table 11 and Figs. 31-32. Parallel to the "might have" case #2 of Table 5 are #1-3 here, with respective subjects: "Joe," "Joseph," and "Josephine." Parallel to the "might not have" case #3 of Table 5 are #4-6 here, with the same respective subjects. The Fo patterns were similar: an apparent small anticipation effect raised the initial peak in Table 11 from 147 to 151, when "not" was included (#4-6 vs. #1-3), just as it did for the quantifiers above (164 to 166 Hz). Similarly, a separation effect lowered the verb's peak here after the "not" (from 125 to 115 Hz), just as the added negative lowered the verb's peak in #3 vs. #2 of Table 5 (from 118 to 111). However, the big difference was the +16 higher peak on the quantifier than on the subjects of Table 11, as well as the large -36 peak differential between the quantifier and the ensuing accented word in Table 5 vs. a -18 differential between "Joseph" or "Josephine" and their ensuing peaks in Table 11. The difference cannot be related merely to an anticipation effect (but note the increasing peaks with longer subjects: "Joe" - 141, "Joseph" - 151, and "Josephine" - 157), because
even the 3-syllable "Josephine" had a peak -8 lower than that on the 2- and 3-syllable quantified subjects. Thus quantifiers, as MOs, received more accent than nouns in comparable utterance-initial positions.

As above, speaker KS in 11:11-13 gave "not" a heavy (+34) accent, with little accent on the preceding modal. Even in #1-3, where the modal was followed by an unaccented aux instead of by "not," he gave the modal primary accent in only 1 of the 4 examples. In contrast, JA gave the modal a +22 accent in #1-3, and even gave it a small +4 accent in cases #4-6, where the +23 accented "not" ensued.

5.1.2.2.2) Quantifiers in the verb group

In Table 13 and Figs. 33-38 (set F), the MO's modal and quantifier exhibited accent patterns consistent with the previous observations. The basic sentence here was "The boys _____ study their books," where the aux-verb group consisted of each possible combination of the quantifier "all," the modal "might," and the aux "have." The Fo peak on the subject varied little in the 7 cases, averaging 148 Hz. The verb had a +18 accent in #1 & 6, which had an unaccented aux immediately preceding the verb, but received less than a +3 accent when the accented "all" or "might" was right before the verb.

Without "all" in #2, the modal's accent was +11 (to a 129 peak), but it decreased to +5 (with a 120 peak) when "all" was present as well (#5 & 7), due to a competition/separation effect. Similarly, the quantifier's accent was +27 (137 peak) when adjacent to an aux (#4 & 6), but +21 (142 peak) when
adjacent to a modal (#5 & 7), and only +8 (129 peak) when adjacent to both
the subject and verb (2 content words). Thus, when both "might" and "all"
were present, the quantifier had +16 more accent than the modal, indicating
its greater strength as a MO.

Interestingly, while "might" decreased -6 in accent with the addition
of "all" (a normal competition/separation effect), the quantifier gained +13
in accent with the addition of the modal (and +19 with the addition of an
aux). Apparently the extra word allowed increased accent on the quantifier,
even where the extra word was itself accented. Indeed, "all" had a large
fall accent when preceding "might" (-26, vs. -11 when following "might" or
adjacent to "have," vs. only -5 when between "boys" and "studied"). Inter-
action between the 2 MOs of quantifier and modal appeared to enlarge the
quantifier's accent; this obviously was a semantic, and not phonetic, effect.

The descent on "boys" was -17 in #1, where the aux and no MO ensued, but
was -34 in #2, 4, & 5, where "might" or "have all" ensued. Thus there was a
bigger descent when an accent was ensuing in the aux-verb group. When "all"
immediately followed "boys" however, the descent was -24, indicating less of
a syntactic break between "boys" and the rest of the utterance. It appears
that the descent on "boys" was less because "The boys all" was actually the
subject in these latter cases. The descent was not more than -17 in #1 be-
cause the ensuing aux continued the Fo fall on "boys" with a further -21
descent. A subject with only 1 accented word normally does not have a
sharp Fo fall-off, except in anticipation of an Fo rise, as occurred in
#2, 4, & 5 above. This trade-off between anticipation of a rise and marking the end of a syntactic unit apparently caused the descent when "all" ensued to be more than in #1 but less than in #2, 4, & 5.

5.1.2.2.3) Quantified objects

The quantifiers were not always spoken as MOs, with heavy accent. In this study, speaker ML uttered 4 of 17 quantified subjects in Table 5 with heavy accent on the noun rather than on the quantifier (however, JA and KS uttered none that way). In utterance-medial position, the quantifier "all" was accented in all cases by speakers JA, KS, and DO (Table 13), but the average accent was reduced as low as +8, when "all" was adjacent to 2 content words.

In set E, JA uttered sentences of the form "Joseph might (not) have studied Q books," where Q represented "his" or one of 6 different quantifiers (Table 14 and Fig. 39). Comparing the results here to similar utterances without a quantifier (11:2 & 5), the relative accents on the MOs preceding the quantifier were reduced. Without the quantifier, the modal showed a peak drop-off of only -5 (11:2); with it, the differential was -24 (14:1-5). Without the quantifier, the negative had a peak increase of +21 (11:5); with it, the differential was only +14 (14:7-11). Further, in a type of anticipation effect, the ensuing verb "studied" had greater relative accent with the quantifier following than otherwise.

The quantifiers as a group here did not have very large accents (the
largest being +21 on "some" in 14:5). Four of the quantifiers ("both," "some," "many," "any") averaged a +13 accent to a 124 peak. The quantifier "these" had only a +5 accent to a 107 peak, which compared unfavorably with a +5 accent to a 118 peak on the pronoun "his" in the same utterance position. Both "these" and "his" exhibited increases of +14 between their peaks and those on the ensuing "books." The other 4 quantifiers above, in contrast, had an increase of only +1 between successive peaks - indicating greater relative accent on these quantifiers than on "his" or "these." The quantified phrase "all the books," with slightly greater accent on "all" than on "his" (+3 more accent, +5 higher peak), also had a +14 peak increase on "books." Another indication of the lesser accent on "these" was that the drop-off from the prior peak on "studied" to that on the quantifier was -31 for "these" and -19 for the other quantifiers.

While "these" might be explained away as a 'weak' quantifier, the overall results indicate relatively weak accent on all the quantifiers here, when compared to those in initial and medial positions. Rather than relate the decreased accent to sentence position alone, it is more likely that these quantifiers received less accent because they were read as demonstrative adjectives, rather than as MOs. Unless controlled by context, this option appears to be a free variant, however consistent a speaker may be in one reading session or another.
5.1.2.3) Adverbs

5.1.2.3.1) Sentential adverbs in the verb group

Into the sentences "Joe might (not) have studied his books," a sentential adverb may be placed at a number of locations. Such adverbs, differing phonetically (1-5 syllables; lexical-stress on the first or second syllable; voiced or unvoiced ASs), were inserted: right after the subject, right after the modal, and right after the aux. In each location, the sentential adverb received heavy accent, reducing other accents in the utterance via competition/separation effects.

When following "Joe" (Table 8 and Figs. 40-41), the adverb had a +21 rise accent to a peak +1 higher than that on "Joe." JA utilized a -18 fall accent as well on the adverb, but KS did not, having only a very small descent on the adverb. The close presence of the accented adverb had little effect on the preceding "Joe" (possibly because the separation and anticipation effects counteracted each other here), but did reduce the accent on the ensuing M0s, relative to the cases without the adverb: -9 less accent on the modal in #1, and -12 less accent on the negative in #2. In addition, the main verb, occurring late in these utterances, had relatively low peaks: 119 in #1 and 113 in #2. As above, JA chose to use 'accent shift' in 2 of the 12 examples of adverb+modal+negative (#3); as a result, the modal's accent increased by +15 over #2, while the negative's +12 accent in #2 was eliminated. (The verb's accent increased (+12 more, +9 higher peak), since the number of preceding USs increased by one due to the accent shift. The larger peak on the adverb in #3 is not related to the accent shift alone, but also to the
adverbs here having unvoiced ASs)

Switching the positions of the modal and the adverb had little effect on the peak patterns (Table 9 and Figs. 42-43), but did prevent any 'accent shift' by JA from the negative to the modal. Splitting the modal and negative apart with the adverb appeared to preclude the option of de-accenting "not" and increasing accent on "might," since "not" was accented in all cases here. Its +10 accent was the same as in Table 8, but again was less than occurred without the adverb present. Similarly, the modal had less accent than without the adverb present; and the verb's accent was less in #2 when the negative preceded, than in #1 with no negative (-10 less accent, -7 lower peak).

Switching the adverb to post-aux position had little effect on the peak pattern other than reducing the peak on the adverb itself (Table 10 and Figs. 44-45). In successive case #1's in Tables 8-10, moving the adverb past the modal reduced its peak by -3 but increased its accent by +7, and moving it past the aux further reduced its peak by -8 and increased its accent by +6. The successive lower peak values are related to the declina-
tion line (i.e., positional effects), whereas the increased accents are due to increased separation. In the similar successive case #2's of Tables 8-10, the first adverb move increased the adverb's accent (+16 more, +8 higher peak), but the second move decreased it (-13 less, -25 lower peak). Thus, the adverb move from before the modal to after the aux had an effect similar to that in the case #1's above (+3 more accent, -17 lower peak). The
increased accent in the second situation (modal+adverb+"not"+aux) is likely an example of increased accent on a non-verbal before a negative. A verbal usually occupies the location before "not;" when a non-verbal occurred there, it tended to receive extra accent, due to the 'marked' situation (see also 6.1.3). In the first and third situations, the adverb averaged less accent (-8 less, -8 lower peak) when the negative was present (cases #2) than not (cases #1), due to a competition/separation effect.

Concerning the negative, its accent was +18 when the adverb preceded it, but +22 when the adverb followed, indicating a possible lowering of accent after an adverb, but not before it; this is similar to the situation in utterances with new/old information words, where old words after (but not before) the last new word in the utterance were much reduced in accent. When the adverb directly preceded the verb, the verb's accent was reduced to only +10 for JA and to zero for KS, due to a separation effect, compared to an average +17 accent when an aux intervened after the adverb. As above, the sequence of "might not" allowed an accent shift, which occurred on 5 of JA's 11 examples in Table 10 (resulting in a +13 increase in the modal's accent, and a reduction of the negative's +18 accent to zero).

In sum, the adverb was a stronger MO than "not," which in turn was stronger than the modal (see Fig. 46). For JA and KS, in utterances with all 3 types of MOs in various positions, the adverb averaged a +26 accent, "not" got a +19 accent, and the modal only received a +2 accent (there were, however, the 7 of 34 examples in JA's speech where accent shift raised the
modal to a +22 accent and eliminated the accent on "not").

5.1.2.3.2) Other Adverb Results

Some other results for adverbs are shown in Table 15 and Figs. 47-48 (for JA). In "Joseph might have ADVERB studied his books," whether the ADVERB modified the entire sentence ("actually," "simply") (15:3) or just the verb ("quickly," "rapidly") (15:4) appeared to have little effect on the verb; however, the peaks on "Joe" and the adverb were +9 and +12 higher, respectively, in #4, which (while possibly related to phonetic effects) could indicate heavier accent on the latter than the former. (Increased accent on the adverb in #4 points this way, but the higher initial peak on "Joseph" as well casts doubt on this possibility).

Deletion of the object ("the books") and movement of the adverb to post-modal position (15:2) had little effect on the subject, but de-accented the modal, and raised the accent on both the adverb and verb (+7 and +6 higher peaks, respectively) relative to 15:3 (probably due to decreased competition). Somewhat surprisingly, the deletion of the adverb as well had little effect on the remaining pattern in 15:1.

Adding an adverbial (e.g., "all night," "quietly") to the end of the basic sentence (15:3) in 15:6 led to a +13 increase on the initial peak (i.e., an anticipation effect) and to a +16 increase on the peak of "books" (previously the final peak, it was raised to allow Fo room for an ensuing accent peak on the adverbial). A small decrease in accent also occurred on the adverb in
medial position ("actually"), possibly in a competition effect. When that adverb was deleted (15:5), there was: less of an anticipation effect on the initial peak, and increased accent on the modal, verb, and object (probably due to decreased competition).

Finally, 15:7-10 used the sentences "Joseph _____ (not) have (actually) studied his books," where the blank contained either "will" or "would" (both 'B' modals). With neither negative nor adverb present (15:7), the verb had its biggest accent. By itself, "not" got a +38 accent (15:8); by itself, "actually" got a +45 accent (15:9). Together (15:10), the speaker chose to increase accent on the negative (+10 more) at the expense of the adverb (-33 less accent). In none of the 4 cases did the B modal receive any rise accent. Following a -25 descent to 150 Hz, Fo on the B modal had a small -10 descent when no negative followed (15:7 & 9); it was even further de-accented when preceding "not" (in 15:8 & 10, the -9 descent on the B modal followed a larger -37 descent to a low 131 Hz). While the former case, where the small -10 descent was followed by a larger -18 descent on the ensuing aux, might be interpreted as a secondary accent, the latter case, where the B modal followed a large descent and immediately preceded the heavy +43 accent of the negative, cannot be so construed.

5.1.2.3.3) Four modality operators in one sentence

Single-clause utterances with 4 different types of MOs were recorded by JA in set E (Table 16). They had the form "Q boys M (not) have (A) studied their books," where Q represents either "many" or "some," M rep-
resents "might" or "would," and A represents one of "actually," "then," or "perhaps." 16:1 shows the pattern for the utterance without an adverb or negative (comparable to 5:2). In an anticipation effect, adding the adverb (as in #2-13) raised the initial quantifier peak by +13 and the peak on "might" by +6, over that in #1. The added presence of "not" in #8-13 decreased the peak on the ensuing adverb by -12 and on the preceding "would" by -8 (but only by -1 on the prior "might"), over that in #2-7. Similarly, the accents on the adverb, "might," and "would" were reduced by -16, -3, and -7, respectively, by the added "not." Thus the 'downstream' adverb (located after the insertion site), with a bigger accent than the modal had originally, lost more accent than did the 'upstream' "might" or "would." Again, the non-MO content words (which also were further from the position of the negative) were not affected by the insertion of "not," except for a -6 lower peak (but +9 more accent) on "studied" as a result of the decreased accent on the preceding adverb. The adverbs "actually" and "then" averaged a +30 accent (148 peak), compared to a +18 accent (136) peak on "perhaps," in the same sentence location here. "Studied," which was adjacent to the ASs of "then" and "perhaps" had accents of +3 and +12, following those respective adverbs (a larger accent following the lesser accented adverb), but had a larger +24 accent after "actually," with its 2 intervening USs for separation.

Following the quantified subject, "might" (an 'A' modal) averaged a +9 accent to a 134 peak, whereas "would" (a 'B' modal) had a lesser +5 accent to a lower 128 peak. In addition to the lesser accent on the B modal, most
of its rise accent occurred early in the syllabic nucleus, while the A modal's rise extended further into the vowel. Also, the accents on the ensuing MOs in #8-13 were +8 larger after "would" than after the more accented "might."

Comparing 5:2-3 with 16:2-4 & 8-10, the addition of an adverb in the middle of the utterance did not appear to decrease the quantifier's accent peak, but rather to increase it, in an anticipation effect, and to increase its relative accent by decreasing that of the ensuing modal (which was closer to the adverb, and more susceptible to a separation effect). Comparing against 10:1-2, the substitution of a quantified subject for "Joe" decreased the modal's relative accent (instead of the modal peak having no drop-off from the first peak, it showed a -53 differential after the quantifier), increased the negative's accent (+11 more), and had a split effect on the adverb (increasing its relative accent without a prior "not," but decreasing it after a "not"). Once again, the modal was shown to be the weakest of the MOs; yet, even when 4 different types of MOs were present in the same utterance (16:8-10), the modal, least accented among the 4, had a +7 accent. Thus, in a neutral context, all MOs should receive accent.

5.1.2.4) Other verb phrases

Whether varying the verb phrase had any effect on the Fo pattern of preceding words, specifically modals and negatives, was examined in the utterances of Table 12 and Fig. 49. Instead of having "... studied his books" as the VP, the sentences here were "Joe might (not) have _____ the
statement," with 4 different verbs: "read" (#1 & 4), "recorded" (#2 & 5), "recognized" (#3 & 7), and "recollected" (#4 & 8) (#1-4 had no negative; #5-8 did). Varying phonetically (1-4 syllables; lexically-stressed on the first or second syllable), these verbs had different accent patterns: "read" had the least (only +7 to a 114 peak), "recorded" and "recollected" had more (+22, 126 peak), and "recognized" had the most (+26, 133 peak). The small accent on "read" was likely due to its **semantic redundancy** in the context of "doing something with a statement" and/or to its short duration of only one syllable.

The object ("statement") averaged a +16 accent to a 115 peak, with little variation over cases #1-8. Similarly, the subject ("Joe") had an average 143 peak, with little consistent variation over the 4 verbs.

The large accent on "recognized" apparently reduced (via competition) the accent on the preceding modal; its accent was +8 with that verb, compared to +12 with the other verbs. The negative's accent (averaging +17), however, was relatively unaffected by the various verbs. The modal's accent was affected by the negative, having a +15 accent without an ensuing "not," but only +7 with one. Thus, while different verbs themselves may have varying phonetics and Fo patterns, nearby accent patterns, in particular those on the MOs, apparently are only slightly affected, via the local Fo effects of **separation** and **competition**.

In set E, JA recorded a set of 9 sentences of the form "_____ might
(have (been)) polarize(ing) the town," where the subject was either "The cold facts," "Many factors," or "The steel factory" (Table 17 and Fig. 50). While "cold facts" and "many factors" were spoken as normal NPs with 2 content words, having a larger descent than prior descent on the second word (on "cold facts," the descent on "facts" was -50, with only a small -12 prior descent; on "many factors," the descent on "factors" was -38, with a -22 prior descent), "steel factory" was uttered as a compound (see 5.1.3), with the second word de-accented (with a heavy -63 prior descent). This large fall-off before "factory" accounts for the relatively low peak on the ensuing "might" there (127, vs. 137 after the other subject NPs).

For some (probably semantic) reason, the modal's accent was +8 more and the verb's accent was -15 less after "many factors" than after the other subjects. This apparent shift of accent from the verb to the modal may be related to the use of a quantifier in the subject (i.e., the use of a quantifier may semantically enhance the accent of another MO in an utterance, in opposition to the phonetic competition effect). The effects of separation are exhibited here on the modal, as a function of the number of ensuing unaccented aux's: preceding 0, 1, or 2 aux's, the modal's accent was +14, +16, and +28, respectively.

5.1.2.5) Adding prepositional phrases

The effects of adding an adjective, an adverb, and/or 1 or 2 PPs to the sentence "The boys might have studied their books" were explored in Table 18 and Fig. 51 (for JA, in set E). The addition of the sentential adverb "act-
ually" (between the aux and verb) raised the initial peak on "boys" by only +3; the successive additions of one and then a second PP to the subject raised the initial peak by +7 and then +3. Thus, while the anticipation effects were small, insertions closer to the start of the utterance had greater Fo raising effects.

The accent and peak on the modal were clearly affected by the length of the preceding subject. With "The boys" as the subject (18:1-4), the modal averaged only a +1 accent to a 150 peak (a -27 lower peak than on "boys"); with "boys in the X" as the subject (X = "dormitory," "dorm," "library," or "classroom") (18:5-8), the modal averaged a +18 accent to a 135 peak; with "boys in the dorm across the river" as the subject (18:9-12), the modal averaged a +16 accent to a 125 peak. Thus the separation of 1 or 2 PPs allowed a +16 accent increase on "might;" but those inserted PPs also had the positional effects of reducing the modal's peak by -15 and then -10. These positional effects were present later in the utterance as well, but with less force; the addition of one and then a second PP reduced the peak on the adverb by -13 and then -7, on the verb by -7 and then -2, and on the object by -2 and then -2. Thus the insertion of extra content words early in the utterance had the positional effect of reducing Fo on ensuing words, but the effect diminished with the distance from the insertion, and the effect of the first insertion was greater than the second.

The adverb averaged a +39 accent to a 155 peak (which was +18 higher than the peak on the preceding "might"). Its presence had little consistent
effect or the peak patterns of the ensuing ASs (although "studied" had +5 more accent after the 2 USs of "actually" than after the one unaccented syllable of "might have"). The addition of an adjective to the object (i.e., ". . . studied their Psychology books" vs. ". . . studied their books") had little consistent effect on the preceding portions of the utterance, other than raising the peak on "studied" by +4 (likely a small anticipation effect). The presence of the adjective did however have a large accent-reducing effect on the ensuing noun: whereas "books" received a +21 accent to a 122 peak without a prior adjective, it got only a +13 obstruction to a low 93 peak with "Psychology" preceding (and since 93 Hz was within the BOR for JA, this indicated little accent on "books"). In the latter case, the adjective instead received the accent (a +23 accent to a 130 peak), which was bigger than the accent on "books" alone. Thus "Psychology books" acted like a compound.

The Fo patterns for the subject with 1 PP (19:1-2) and 2 PPs (19:3-4) exhibited the little effect that the insertion of an extra PP had on the preceding portion of the utterance here. That there was little consistent change on the subject's Fo with the addition of either "Psychology" or "actually" is seen by comparing 19:1 & 3 with 2 & 4. The insertion of a PP after "boys" had the effect, however, of making the enlarged subject a P-unit, with a large rise on "boys" and a large (-43) fall on the prepositional object. Correspondingly, the -28 descent on "boys" in 18:1-4 was reduced to a -15 descent in 19:1-2. After this smaller descent, Fo fell-off only -32 Hz total on the 2 USs "in the," to a 138 level (well above
the BOR); the final accented word in the P-unit then had a +23 rise and
-43 fall accent (to a lower 118 level, close to the BOR). This pattern
showed little alteration when the second PP was added (19:3-4). The second
PP ("across the river") formed its own P-unit of sorts: a +25 accent on
the preposition (140 peak), followed by a small -17 fall-off on "across
the," and then a +19 rise and -29 fall accent on "river." Thus, in both
cases, the PP ended in a rapid fall indicative of the end of a syntactic
unit, while the medial USs in the PPs fell at a slower rate. The preposition
"across" received accent here because it is a polysyllabic preposition, and
is in the class of "intermediate" words, which get some accent (while
strictly function words do not).

5.1.2.6) Reflexive pronouns

Unlike other pronouns, reflexive pronouns, although forming a closed
class, received accent in their normal usage, and may be considered as in the
MO class. Table 45 shows Fo data for the pronoun "himself" in 3 different
positions in the same basic sentence ("Richard _1_ prepared _2_ the
casserole _3_ "). In position #1, "Richard himself" formed a P-unit with
a very sharp -66 descent on "-self," marking the end of the subject. In
medial #2, "himself" had less of a fall accent, but segmented the utterance
with a +13 CR, thus marking a break before "the casserole." In final position,
"himself" once again had accent (a +36 rise accent, since the pronoun formed
a syntactic unit by itself in #3). The location of "himself" had little Fo
effect on "Richard," but had the usual 'carrier' effect on "casserole" (a +16
higher peak there when "himself" followed rather than preceded). This effect
was even more pronounced in "prepared:" its peak was -42 lower in #1 than #2-3. Reflexive pronouns in general add little information to the sentence, but when it directly follows its antecedent (as in #1), its sole function is to 'focus' upon the antecedent ("Richard"), leading to decreased accent on ensuing words in the utterance.

5.1.2.7) Accent priority list

5.1.2.7.1) Foundations in the data

A major finding of this thesis involves an ordering or priority-listing of the word-classes for receiving Fo accent in an utterance. It was not the case that all the words in a particular form-class had one certain amount of Fo accent. Just as there is no firm boundary between ASs and USs (qualitatively, they form separate classes, with the ASs having more Fo accent than the USs, and are used in this thesis in complementary distribution; but since quantitative Fo accent is continuous, any firm boundary 'x' Hz (such that x+e Hz would mark an AS, while x-e Hz would mark an US) cannot be considered valid without extensive perceptual tests), there was no firm correspondence of amount of accent to any one set of words. Instead, the various word-classes in English displayed an accent-priority system, in which certain IC word classes at the high end of the list were likely to receive strong Fo accent, whereas classes at the low end were likely to be completely de-accented. The likelihood of any given word receiving accent in an utterance depended on its position in this list, as well as on several other factors.
From the Fo data, a tentative list of the likelihood for a word to receive accent was obtained (proceeding from most to least likely): sentential adverbs, negatives, interrogative pronouns, dummy aux's in positive sentences, quantifiers, reflexive pronouns, 'A' modals, adjectives, regular adverbs, nouns, negative contractions, verbs, demonstrative pronouns, prepositions, aux's (including 'B' modals), and articles.

This ordering was obtained by comparing the Fo patterns on examples from each of the word classes involved, in various controlled sentence positions and competing for accent with other words on the list. When words in differing sentence positions were compared, a linear compensation in decreasing Fo accent was allowed to help account for the tendency of larger accents to occur early in the utterance. For example, the ordering of sentential adverb > negative > A modal > verb > aux can be seen in Tables 8-10, in which the adverb occupied several sentence positions with respect to "might," "not," and "have." Considering only the voiced adverbs (for JA) (which had about 13 Hz less accent than the unvoiced adverbs), they had an average of +25 accent, compared to +12 for the negative "not" and +7 for the modal "might" (Fig. 46). In this same group of sentences, 27 of 34 cases in which both a modal and a negative were present exhibited a +18 accent on "not" and only +4 on the preceding modal; in the other 7 cases, the accent shifted to the modal (+21 accent) with only a +1 average accent rise on the negative. These observations and the results that, in all 6 modal+"not" sentences shown in Table 3, the negative averaged +22 accent to the modals' -8 fall, and that 10 of 15 utterances of the type modal+"not"+
aux (4, #2) showed primary accent on "not" rather than the modal, led to the ordering of negatives over modals in the accent list. In addition, speakers KS and ML had considerably more accent on the negative than the modal.

Table 2 can account for the ordering of dummy > modal > negative contraction > verb > aux. In similar utterance positions, the dummy averaged +13 accent, the modal, +16, the negative contraction, +6, and the aux, no accent (the dummy, while having less accent here than the modal, was more consistent in accent). The ensuing main verb showed an accent jump only after the unaccented aux, and thus ranks lowest on the accent list among the content words. More evidence for the ordering of modal > negative contraction > verb > aux came in Table 3, in which, for JA, 12 of 15 A modals and 11 of 15 negative contractions received primary accent (of +27 and +15, respectively, for syllables with voiced initial consonants, and of +38 and +27, respectively, for the unvoiced cases). Only in the other 7 (of the 30 cases), where the modal or negative contraction received secondary accent, did the verb approach the amount of accent seen when following two unaccented aux's, rather than following a negative contraction or modal+aux. On the other hand, KS exhibited greater accent on the contraction than on the modal here.

In distinguishing between A and B modals, where A modals receive more accent than B modals, which are in turn classified with the other aux's due to their Fo similarity, one must include "will," "would" and "can" among the B modals, since they never showed primary accent in this study, and include
"may," "might," and "must" among the A modals, since in 18 of the 22 simple utterances of JA's they appeared in, preceding 0-2 aux's, they had primary accent rises. However, the remaining modals, "shall," "should," and "could," might be classified as intermediate between class A and B, since only 3 of their 9 examples had primary accent. In the more complex sentences (i.e., those with adverbs, quantifiers, etc.), "might" was used as the typical A modal, and either "will" or "would" as the typical B modal.

Table 13 shows well the ordering of quantifier > modal > verb, since there "all" had +17 more accent than "might" in the same sentence positions, and "all" got the major accent when both occurred in the same utterance. Again, the verb got an accent jump only after an unaccented aux, and not after either a modal or a quantifier (except for small accents in 2 of the 10 examples for KS and ML). Tables 5 and 11 illustrate why quantifiers are listed over nouns on the accent list, since they averaged a 163 peak in the non-contrastive utterances, compared to a 153 peak on "Joseph" and "Josephine" in similar sentences. When treated as demonstrative adjectives by the speaker, however, quantifiers receive less accent (Table 14), and occur lower on the accent list.

5.1.2.7.2) Linguistic explanations

Sentential adverbs occur at the top of the accent list as the most likely words in the corpus to receive heavy F0 accent, and clearly fall in the class of MOs. They express such delimitations on the nucleus as the circumstances under which the nucleus is to be considered (e.g., when, in
what manner or context the proposition is to be taken, how probable the proposition is, etc.). The sentential adverbs place above the other operators on the accent list most likely because they form an open class and are relatively free in sentence position. Unlike the dummy aux's, negatives, quantifiers, and modals, which form closed classes, the membership in the adverb class is open; the frequency effects mentioned above, in which word classes with more members are more likely to get accent (since each member has a lower a priori probability), come into play with the sentential adverbs. In addition, these adverbs have considerable freedom as to where they may occur in a sentence, as opposed to the relatively rigid positional requirements for quantifiers, negatives, dummies, and modals; due to their positional freedom, sentential adverbs cannot be easily anticipated by a listener, and thus a speaker tends to accent them to highlight their occurrences.

The interrogative pronouns (see 6.1.3) place high on the accent list and can be considered MOs, since they express requests by the speaker for specific information, and thus indicate his attitude toward the proposition, viz., he wishes the information from the listener which is represented by the interrogative pronoun in the question utterance. Yes/no questions (6.1.2) request similar responses from the listener, but there is no particular word in these questions to which the listener is expected to pay specific attention in the same manner as he is to the Wh-words in the Wh-questions. Rather than focussing on a particular word in the yes/no questions, the speaker raises his Fo over the end of the utterance as a unit to mark it as a question for
the listener.

Dummy aux's in positive sentences and negative adverbs are high on the accent list because their clear understanding by the listener is important to whether he interprets the proposition as being true or false, respectively. Were it not for the presence of the negative, the nucleus would be assumed true, thus negative sentences require a negative adverb or adjective; positive sentences, on the other hand, do not require dummies (except as placeholders - where they occur unaccented), but they are used in positive sentences in a type of 'emphasis of affirmation,' usually when the nucleus is predictable, and the speaker's sole objective is to convey the idea that the proposition is true.

Quantifiers are high on the accent list because they restrict the set of items for which the proposition is true or false; their presence in a sentence often indicates the delimitation of a concept known previously to the listener; thus the quantifier provides 'new' information to the 'old' concept. Reflexive pronouns have the apparent function of drawing attention to the antecedent. The proposition remains unchanged, yet the speaker succeeds in emphasizing one particular word in it.

The accentual differences between A and B modals can be explained in terms of "modality" vs. "modulation" (Halliday, 1970). The modals in the A group receive Fo accent because they indicate the speaker's feeling about the proposition, i.e., what likelihood he believes it is true (e.g.,
"may," "might," "could"), or how he personally feels about the proposition ("must," "shall," "should"). On the other hand, the B modals ("will," "would," "can") have Fo patterns similar to the unaccented aux's (low on the accent list), because they perform a modulation, rather than a modality, duty. While not strictly contained in the nucleus, their delimitation of the proposition has a function similar to that of the other aux's, and involves no explicit attitude or commitment on the speaker's part.

Negative contractions fall lowest on the list of MOs, but still above other content words (such as verbs) and well above all the function words on the accent list. Being a combination of a positive aux and "not," which respectively would be unaccented and accented separately, the negative contraction appears to occupy a middle ground accentually. Contractions generally occur where the information to be presented by them is somewhat redundant or understood, and the speaker wishes to spend less time and effort producing them. Contraction formation in English is a method by which the speaker attempts to convey the same linguistic information in a shorter time span, with less phonetic segments. Often it indicates that the 'information' present in the two words that become contracted can be just as easily conveyed in one contracted word.

In positive contractions, the operation takes the form of appending a truncated aux-verb onto a preceding word (usually the subject, or another verbal), where the aux loses its vowel. Since the amount of linguistic information ordinarily conveyed by the aux (an unaccented function word) is
minimal, the Fo contour behaves as if the aux had been deleted. In cases where some reduced form of the syllable remains (as in the reduction of "have" to "'ve"), the Fo contour is essentially unchanged (cf. Figs. 24a-b vs. 24c). Thus, positive contractions exhibit little change in the Fo contour (other than time compression); even when the contracted version loses a syllable (e.g., "Joe has" - "Joe's"), the only Fo effect is the deletion of that syllable's Fo pattern (cf. Figs. 18a vs. 15b).

In negative contractions, on the other hand, the word losing the vowel is "not," and the word to which it contracts is an aux or a modal verb. Contracting an accented "not" causes the Fo contour to change: the Fo rise on the negative shifts to the preceding verbal with which it contracts, most likely because the negative loses its vowel while the aux does not, and syllabic nasals (as in "-n't") never receive Fo accent. As a MO, "not" carries a significant amount of linguistic information, which must be carried elsewhere after the contraction operation. Since it often contracts with a word with little linguistic content (e.g., an aux), that word provides a good carrier for the transferred information of the negative. Thus while sequences of aux+"not" have the accent on the latter, the contracted aux+"n't" has accent on the aux portion, and the aux becomes, in effect, an accented word. The accent decreases in a negative contraction, likely due to the inherent de-emphasizing nature of all contractions.

The contraction of "not" (and resultant shift of accent) can produce ambiguous interpretations: "Joe hasn't studied" could result from normal
negative contraction, but also from "Joe has not studied" (with CS on "has"). Contrastively-accented aux's cannot be contracted into the subject without losing accent and changing meaning; whereas normally-accented "not" can be contracted into the prior verbal without change in meaning. Due to the possible ambiguous interpretations of negative contraction, it should not be used in situations with CS on the aux.

Below most of the MOs on the accent list are the remaining content words, such as adjectives, non-sentential adverbs, nouns, and verbs. The verbs are lowest on the scale of accent because they are more easily predictable from context and because there are less members in the word class verb than in other open word classes, thus leading to higher a priori probabilities for each verb than other content words (as mentioned above, rarer words are more likely to receive accent). Adjectives and adverbs are higher on the list than nouns because the former function as delimiters of the latter in the proposition; thus the nouns and verbs, as the basic elements of the proposition, are the lowest of the content words on the accent list.

5.1.2.7.3) Summary

The accent ordering was obtained from sets of sentences controlled for syntax, semantics, and phonetics, and illustrates that words high on the list inherently receive the biggest accents. However, the amount of accent a word gets was found to be subject to several contextual effects, both of the phonetic type (separation, competition, anticipation, and carrier effects) and of the semantic type (treated further in 5.1.2). In utterances
with the same context, however, free variation also appeared; e.g., while "not" averaged more accent than "might," there were cases where "might" had more; since there were no linguistic or phonetic differences to account for the Fo change, it was treated simply as one example of Fo free variation.

What this accent ordering indicates is that items such as sentential adverbs and negatives are most likely to be the focus of any sentence they occur in, thus having the largest Fo obtrusion in that sentence. When more than one IC word occurs in a single sentence, the word higher on the list is most likely to be the 'focus.' The IC words tend to have larger and more 'resilient' Fo accents, i.e., accents less susceptible to de-accenting due to the proximity of another AS. In the corpora, virtually all adverbs had Fo accents, even when surrounded by A modals and negatives. These other PA elements caused a decrease in the amplitude in the Fo peak on the adverb, but the accent remained nonetheless. Less resilient, but still IC, were the negatives and A modals. In utterances without other IC items, they virtually always (negatives, especially) received Fo accent. Only when they occurred in utterances with other contrastive elements did they tend to lose Fo accent, and then only to stronger elements, such as adverbs and quantifiers.

5.1.3) Compounds:

Another lexical factor in determining which words are likely to receive accent concerns compounding. The words in many adjective-noun and noun-noun sequences in English tend with time and usage to become readily associated with each other as fixed combinations. Thus, while two such content words
in sequence usually each receive a certain amount of accent (since each represents unpredictable information), in compounds only the first has accent (Bolinger, 1968b:72; Cushing, 1969:351; Vanderslice & Ladefoged: "all accents after the first are dropped in compounds" (1971:16)), since the 2 words in a compound are treated as a single unit, and, like single words, need only one accent (compounds treat the first word as having the 'lexically-stressed syllable'). (That the accent goes on the first syllable is indicative of English, in which most words have the initial syllable stressed.) For adjective-noun combinations not yet accepted as compounds in English (Bolinger, 1958b:81), which of the two words receives accent is likely determined by which is the least predictable of the two in context (72). Table 17 shows that "steel factory" acted as a compound, while "cold facts" and "many factors" in the same sentence location did not.

5.1.4) Accent shift

When a sentence contains more than one content word, there is competition for the highest accent (or 'focus') in the sentence among those words. As defined by the accent-ordering list given above, certain word classes are more IC and likely to receive heavier accents than others. Ordinarily the word highest on the list gets the biggest Fo accent, but sometimes the speaker chooses to give a lesser IC word the biggest accent. Since this is a type of deviation from the norm, it is a form of emphasis on the speaker's part.

In this study, the speakers were asked not to use special emphasis, and
little evidence of unusual emphasis was found. However, a certain form of emphasis did arise, which one might call 'contrastive accent shift,' which involved a shifting of the main, focus accent from one IC word to that of another IC word lower on the accent list. Since all IC words are likely to have accents, a shift of main accent among them was not judged to be a form of free emphasis, but rather a more restricted operation that has little effect on the interpretation of the utterance. The acoustic correlates of such an accent shift were that the word gaining the main accent achieved an even bigger Fo accent obtrusion than was the case without the presence of the other IC word (the one losing main accent), and further that this latter word was heavily reduced in accent. This is the basic result of free emphasis as well; only there, all the non-emphasized accent words in the sentence become lowered in accent, rather than just a specific one (since free emphasis is a choice of one word over all the other words in the sentence, whereas IC accent shift occurs specifically at the expense of one IC word). In this study, contrastive accent occurred when a modal and a negative occurred sequentially. Most examples of this situation had the main accent on the negative, with a secondary accent (at best) on the modal (as per the accent list). With the accent shift, the negative was de-accented and the modal received primary accent.

5.1.5) Summary

In this section on lexical Fo phenomena, certain classes of words (content words and MOs) were found to have more accent than others (function words). Words least predictable from context (e.g., sentential adverbs)
had more accent than those more easily anticipated (also e.g., since "not" is usually preceded by an aux or modal, a non-verbal before "not" tended to have more accent). Words selected from a large open class, each having lower probability of occurrence in context, had more accent than those from smaller word classes. Within a word class, less common words (e.g., "across," "recognized") had greater accent than more common words (e.g., "in," "read"). Words expressing the speaker's attitude toward the utterance content and words crucial to the interpretation of the utterance (e.g., negatives, dummies, M0s in general) had more accent. Contracted words had less accent than uncontracted words. Common word combinations (e.g., compounds) had reduced accent on their second elements.

These inherent accent tendencies for words were subject to modification within actual utterances. The phonetic effects of position, separation, competition, and anticipation all act to change the basic accent of a word when it interacts with other words in an utterance: accent and peak levels decreased as the utterance progressed; nearby ASs detracted accent from each other; the presence of more ASs in an utterance decreased the accent of each; the speaker often 'anticipated' a longer utterance by raising his initial Fo, 'anticipated' more words in the remaining portion of an utterance by keeping Fo high, and 'anticipated' an accent rise by lowering Fo before the accent.

In addition to these phonetic effects, the inherent accents were modified by semantic interactions. While the presence of an extra AS usually de-
creased other accents in an utterance, some MOs tended to increase accent on other MOs (e.g., the presence of an adverb or modal raised accent on a preceding quantifier). Similarly, the adjacent presence of a modal and a negative allowed a free variant form of 'accent shift.'

5.2) Contextual effects:

5.2.1) Distribution of information

5.2.1.1) New vs. old information

The major semantic role that Fo plays is in highlighting the less predictable words ('new information' words) in an utterance, via the use of heavier Fo accent on these words than on the more predictable 'old information' words. This Fo effect of 'focus' is keyed to the division of a sentence into topic and comment, or old and new information. Most sentences in discourse contain words which have been stated in earlier sentences, thus establishing them as a known 'topic' ('old' information). Yet each sentence usually contains some ideas not expressed in the earlier ones; these ideas are implemented in the 'comment,' which contains 'new' words and usually occurs late in the sentence (i.e., after the topic).

In general, the 'new' words receive Fo accent, while 'old', repeated ones do not. Of course, new/old information is a time-varying operation with limited memory; hence a word mentioned several sentences earlier may indeed be re-considered as new information if brought into the discourse again. Hultzen refers to the new information words as "information points" which occur "wherever the speaker has freedom of choice in what he says, where it
cannot be predicted what he will say" (1959:107), and theorizes that
"some aspects of intonation can be explained as marking information points"
(111). Lee also notes intonation's role in "pointing to and emphasizing
the new elements" in an utterance (1956:363).

Bolinger notes "the systematic relationship . . . between . . . high
pitch . . . and the semantically most important item" in a sentence (1958c:97),
and says that "the role of pitch change . . . is to focus on important words"
(100). The speaker puts "the primary accent on the semantic 'point' of the
utterance, the element that carries the greatest freight of information"
(1957:311), the one with the most "semantic weight" (1972a:635). "What is
involved is the de-accenting of repeated [i.e., 'old'] elements and the
accenting of new elements" (642), to "distinguish old from new or topic from
comment" (1964a:843). "A lower pitch may be used for theme than for rheme"
because "themes are generally less interesting" (844).

Yngve found that, if a speaker is interrupted in conversation, "in re-
turning to the conversation sometimes he goes back to the beginning of a
phrase or clause and repeats perhaps several words up to the point where
he had broken off" (1973:692); this repeated speech constitutes old infor-
mation, and "is speeded up; there is stress reduction." However, after the
break point, the ensuing speech "is fully stressed, normally paced," since
this is new information (694).

Lieberman found that his "speakers produced . . . non-redundant words
with more stress," that "differences in stress will call attention to words in context" (1963:181), and that "the degree of stress . . . [is] approximately inversely proportional to the operational 'total context' measure of the redundancy" of the spoken words (185).

5.2.1.2) Predictability

The terms 'new and old information' need further elaboration: there are actually two different concepts involved. A word repeated in discourse is said to be an 'anaphoric' occurrence, in contrast to the original occurrence; this is the idea of old/new applied to lexical items. When "applied to the particular semantic relations which the lexical items enter into in the given sentence" (Kuno, 1972:272), one relates 'old information' with that which is predictable from the context (which is often, but not always, anaphoric), and 'new information' with that which cannot be predicted (which may or may not be anaphoric). For example, in the Q/A pair "Does Joe want the medical or biology books? Joe wants the medical books.", although "medical" is anaphoric in the answer, it is still 'new' information, compared to "Joe" which is 'old' information.

While "in general new items are stressed," "it is not simply a matter of repetition or of new vs. old. Rather . . . , the element referring to a subset of the originally given element is stressed; whereas an element referring to the same set (repetition, for instance) or to the set which includes the one originally given as a subset is unstressed" (Wode, 1972:1062), which can be explained in that a subset requires further modification of the
set, which adds new information, resulting in more accent. Similarly, Vanderslice & Ladefoged note that word pairs like "hat" and "helmet," which "name only partially intersecting semantic categories," would not allow de-accenting, but that "hat" and "headgear" would (1971:12). They note that, with old/new relationships, "there is a progression through optional pronominalization and optional ellipsis;" they find that, in the sentence "This is the brown house, not the grey house," the second occurrence of "house" (being a repeated word and unaccented) can be replaced with "one" (also unaccented), or deleted entirely, without change in the sentence meaning (12; Hirst, 1974:10).

Although 'old/new' is often used in the anaphoric sense, in this thesis it is used in the latter 'predictable/unpredictable' sense, since it is this sense that relates most closely to Po patterns and to FSP. The difference between the two is mainly one of 'contrastiveness:' the new information is generally a subset of the non-anaphoric words, except when two or more similar lexical items (e.g., "Tom, Dick, and Harry," or "medical and biology books") are introduced into the discourse, in which case the lexical features which cause the similar items to differ from one another are eligible as new information, even though anaphoric.

One way to view the development of new/old information in a discourse is to consider "that there is some common stock of knowledge shared by the participants of a discourse", and that "this stock of knowledge is being modified during the discourse," having existed "already at the beginning of
the discourse" (Sgall et al, 1973:375). Chafe has referred to old words as being "foregrounded," i.e., "assumed to be in the hearer's consciousness," and having "low pitch and amplitude" (1972:50-51). "The terms 'given' and 'new' are to be interpreted, not as 'previously mentioned' or 'not previously mentioned,' but as 'assigned' or not assigned, by the speaker the status of being derivable from the preceding discourse.' Thus what is treated by the speaker as given may not in fact have been said, and what is treated as new may be contrastive or contradictory" (Halliday, 1967a:5).

Ohala notes: "The manifestation of pitch accent on . . . words in a sentence indicates the relative importance or informativeness of these words—from the point of view of the speaker" (1970:116); "old information" is "obligatorily de-accented" (99). Bleakley states: "stress occurs with a word or group of words which the speaker regards as providing information not previously known to the listener;" "when a listener perceives stress he is made aware of the fact that the speaker regards the word or group of words with which stress occurs as providing information not previously known." "Thus, a word or idea already mentioned in the immediately preceding context will not be stressed unless the speaker wishes to distinguish it from a number of previously mentioned words or ideas," and "if the speaker does not stress a word or idea which has not appeared in the preceding overt context . . . , then the listener must assume that there is some covert context (e.g., . . . a shared area of knowledge . . . ) to which the utterance refers" (1973:45).
As discussed above, not all words repeated in context are predictable by the listener. If 2 or more similar lexical words have occurred in the prior context, the listener cannot predict which of the alternatives might occur in a particular syntactic framework in an ensuing sentence, and hence the speaker must still accent later occurrences of those words. One factor which complicates this analysis is that the concepts of 'old' vs. 'new,' or predictable vs. unpredictable, are far from binary. There are few situations in which the listener can completely predict what words a speaker will utter; similarly, the listener, depending on his knowledge of the speaker, inherently 'knows' the approximate expected vocabulary which will occur in any conversation between the two, and thus no word is completely unpredictable. The difficulty of placing a quantifiable measure on the 'predictability' of a word in a given context precludes any simple mathematical relationship between that concept and Fo accent. However, from an analysis of the Fo contours, one can posit the existence of a roughly proportional relation of Fo accent to 'unpredictability.'

There is evidence in the data that the reduction of the set of words that a listener might expect in a given sentence, from a very large group (as in a citation situation) to a small number of alternatives (via an explicit context), leads to a reduction in Fo accent, despite the speaker's remaining need to accent a word in this situation so as to distinguish among the remaining alternatives; that is, increased expected probability on a set of words would lead to decreased accent on any word-occurrence from that set. Clouding this intuitively-reasonable conclusion, however,
is the fact that accents are often increased in 'parallel' structures (see 5.2.2), when items from a set occur in parallel positions. However, since not all words from a homogeneous, mentioned set occur in ensuing overtly parallel situations, the hypothesis of accent roughly proportional to the number of alternative words may be tentatively advanced. This does not mean that the speaker, before he utters a word in an utterance, calculates probabilities of occurrence to determine the amount of accent to be placed on that word, but rather that he roughly gauges how likely the listener is to anticipate the word, and accents it accordingly.

5.2.1.3) Anaphora

In anaphora, two different lexical items are used to refer to the same concept or object. Rather than repeating the same words each time an item is mentioned in a discourse, a speaker often uses a pronoun on occurrences other than the original. Such personal or relative pronouns are function words and usually receive little accent. In addition, "semi-pronouns, like 'people,' 'things'" often are not stressed (Bresnan, 1971:271). However, Bolinger has criticized this analysis of "semi-pronouns," noting that "the accentual behavior with true pronouns is predictable," but "that of [such] empty nouns is only highly probable" (1972a:637). Saying that "accent responds to the degree of emptiness," he claims that "pronouns are formal deictic elements that are semantically empty," whereas so-called "empty nouns" have varying amounts of information (and hence varying accent) depending on context (636).

Nickel claims that "an NP in a given sentence always carries the primary
accent when introduced for the first time. If mentioned for the second time it can only carry a secondary accent" (1970:672). If there is no new NP in a sentence, "the rhematic accent is automatically given to the verb" (672). Bresnan notes that an NP introduced for the first time with an i-definite article receives stress, but successive occurrences with the definite article signifies an anaphoric relationship, which de-accent this occurrences (1971:271). Noting that "anaphora . . . is not a lexical property," Lakoff points out that "pronouns may . . . occur stressed, under a number of conditions, such as deictic use, contrast, etc" (1972:291; also Schmerling, 1974a:608, 615). Both he and Berman & Szamosi (1972) note that NPs other than pronouns or the original NP can be used coreferentially and receive "anaphoric stress reduction" (310) (e.g., "hat" and "headgear"); verbs can also be used anaphorically (e.g., "jail" and "incarcerate," in Ohala, 1970:112).

5.2.1.4) Question-and-Answer context

The sentences in this section were spoken as the answers to questions: the speaker uttered the question, and then after a pause, the answer, as if responding to the question in a dialogue. The objective was to create a specific context for the answer utterance. Wode has noted the role a Q/A context can have on old/new information and intonation. In answer to a Wh-question, "the intonation center of the reply is on the interrogated constituent" (1972:1059); information "not given in the question and added to the reply" must be new information and "have their own intonation center(s)" (1060; Schmerling, 1971:243).
In Table 20 and Figs. 52-56, the Fo patterns for 2 citation utterances (#1 & 6) are compared to those of 6 Q/A utterances (#2-5 consisting of the same sentence as in #1 ("The farmer was eating the carrot"), but in answer to 4 different questions; #7-8 similarly correspond to #6, which used a clefted sentence ("It was a farmer who was eating a carrot")). In the citation case (#1), each of the 3 content words provided 'new' information and each received Fo accent, with "farmer," "eating," and "carrot" getting rise accents of +54, +23, and +20, respectively. The peak pattern of 158-125-126 (i.e., 158 peak on "farm-", 125 peak on "eat-", 126 peak on "car-") indicated less relative accent on the verb than on the nouns, because of the large drop-off between the peaks on "farmer" and "eating;" this result followed the general trend toward less accent on verbs than on nouns.

When a question preceded the sentence, as in #2-5, the content words mentioned in the question provided 'old' information in the answer, and as a result, received reduced accent. In #2-4, the questions "Who was eating the carrot?", "What was the farmer doing with the carrot?", and "What was the farmer eating?" led to only one content word in each answer being a 'new' one: "farmer," "eating," and "carrot," respectively. In each case, the new words retained accent, while the old words lost accent, relative to #1. The peak patterns in #2-4 exemplify the situation: 155-99-98, 125-155-101, and 123-115-153, respectively. The inter-peak drop-off after the soleaccented-word peak was -55, compared to at most -33 in #1. The peaks on the old words after the sole new word were very low (within or just barely above the BOR), and the peaks before the new word also were relatively low for
initial peaks in an utterance. These latter however remained above the BOR, since the very low Fo occurred only after the main accent of the utterance. There appeared a tendency for Fo to remain at a middle level through the initial old words in an utterance, with Fo then rising up on the new word, followed by a sharp Fo fall-off to a low level in the rest of the utterance.

Besides the Fo peaks, the accents on the content words in #1-4 reflected the new-old information pattern: compared to a descent of -24 on "farmer" in #1, it was -51 on the sole new word in #2 and -16 in the old word cases #3-4; compared to an accent of +23 on "eating" in #1, it was +54 as the new word in #3 and only +12 in #2-4; compared to an accent of +20 on "carrot" in #1, it was +44 in the new word case #4, and +19 in old word cases #2-3.

When the preceding question was "What was the farmer doing?", only "farmer" was 'old' in the answer, whereas "eating" and "carrot" remained 'new.' Thus, in #2, both new words had increased accent compared to that in #1 ("eating" had -13 more fall accent, "carrot" had +19 more rise accent), whereas "farmer" had 16 less descent. The peak pattern of 126-126-144 displayed a low peak on the old "farmer" similar to those on the other old "farmer"'s in #3-4; on the other hand, the peaks on "eating" and "carrot," while greater than the values on the old versions of these words in #2-4, were less than on the new versions in #3-4. In this 'competition' effect, the accent on a new word was greater if it was the sole new word in the utterance (as in #2-4), rather than having to compete with another new word (as in #5).
While all 3 speakers had decreased accent on the old "farmer" in #5, as compared to #1, JA increased accent on "eating" while decreasing it on "carrot," whereas the other 2 speakers did just the opposite. Thus when one of the 3 content words became old information, the choice of which of the other 2 content words was to receive increased accent varied among the speakers: JA selected to enhance the verb's accent at the expense of the noun, while KS and DO chose the opposite course, which actually was more in keeping with the hypothesis of greater tendency for accent on nouns than verbs.

The Fo effects of combining clefting with a preceding question is shown in Table 20, where #6-8 were clefted utterances of the type "It was a farmer who was eating a carrot;" #6 was the citation version, #7 was preceded by "Who was that?", and #8 by "Who was eating a carrot?". The peak patterns were 159-108-114, 150-116-129, and 164-96-97, for #6-8, respectively. #8 had an accent pattern similar to that of #2, since both cases had the same situation of old/new words. However, the accent differential between the new "farmer" and the old content words was even greater in #8, most likely because of the added factor of clefting, which focused on the initial "farmer," regardless of the prior question (see 5.3.2).

A comparison of #1 & 6 indicates the difference clefting made among the citation utterances (-17 and -12 lower peaks on "eating" and "carrot," respectively). Yet the Q/A context further decreased the accent on these words (-12 and -17 additional peak decreases), because words de-focused by a
transformation retain more accent than old information words.

The presence of a prior question can affect the answer's Fo pattern, even when no content words appear in the question. For instance, all 3 content words were new in #6-7, yet the Fo accent patterns differed. The presence of the prior question "Who was that?" in #7 diminished the Fo focus pattern present in #6, by reducing the accent on the focused "farmer" (-20 less descent, -9 lower peak) and increasing it on the de-focused words (+8 and +15 higher peaks on "eating" and "carrot"). Thus while the new/old word pattern was not disturbed by the preceding question, the introduction of an animate entity into the discourse (i.e., "who") was sufficient to alter the clefting-structured utterance into a non-focus utterance.

5.2.1.5) Repetition within one sentence

Among sentences with no external context, repetition of words in successive conjoined phrases or clauses can lead to effects similar to new/old information. In Table 21 and Figs. 57-60, sentences of the form "He bought a red car and a _____ _____" illustrated such effects. The last 2 words in #1-3 were: "red blouse," "blue car," and "blue one," respectively. Thus, in the second NP, one word was either repeated ("red" in #1, "car" in #2) or a function word ("one," a pronominal referent for "car," in #3).

In the same utterance position in #1-3, "blue" (a new word) had more accent than "red" (a repeated word) (+4 more accent, +12 higher peak); similarly, the new "blouse" had a prior descent of only -5 Hz, compared to a
-32 prior descent for "car" or "one" in #2-3. Thus while the Fo effects within these utterances were not large (e.g., the old "red" in #1 still received accent, albeit a reduced accent), the presence of a repeated word did alter the Fo pattern by shifting accent from that word to other nearby words.

These Fo effects were less than other new/old phenomena because they involved lexical repetition rather than strict anaphoric relationships; e.g., the repeat occurrences of "red" or "car" in the second NP were not really 'old information' since "red blouse" and "blue car" were not mentioned previously. Thus, the repeated words tended to lose accent, but not as much as when true old information.

Whereas little Fo difference occurred between the phrases "blue car" and "blue one" of #2-3, the initial accented word "bought" had more accent in the latter case (+24 higher peak). This rather large difference is likely related to the parallel structure of the object NP: in "He bought a red car and a blue car," the 'unnecessary' repetition of the word "car" (when "one" could be substituted instead) apparently led to emphasis on the object at the expense of the verb (which had an abnormally low 114 peak for a new word in initial position). In the other object NPs ("a red car and a red blouse," and "a red car and a blue one"), no further pronominalization could occur, and the relative accent on "bought" was greater than in #2.

In #4, the sentence had a 3-NP object ("He bought a red car, a blue car, and a blue coat"). The single occurrence of "coat" had relatively greater
accent than "car" here; "car" did not have much accent in either occurrence (having -20 and -27 prior descents in the first and second object NPs, respectively), compared to a +5 increase in Fo between the peaks of "blue" and "coat" in the third NP. The peak on "coat" was higher than that on the second "car" (127 vs. 120), even though "coat" was the utterance-final word (normally, lateAs have relatively low Fo). This higher accent on "coat" can be related to 2 factors: "coat" being a new word and the preceding word ("blue") being a repetition. Similarly, the second occurrence of "car" had less accent than the first one.

In the conjoined NPs of the object, most non-final NPs were marked with CRs of varying sizes. In #1, the CR averaged only +8; whereas in #4, the first 2 NPs had CRs of +31 and +19. This exemplified the typical pattern of larger CRs in co-ordinated units of more than 2 phrases, and larger CRs earlier in the utterance than later. Among cases #1-3 for KS and DO, "a red car and a blue car" had the biggest CR (+7), and "a red car and a blue one" had no CR. This difference probably is related to the difference in parallel structure; the parallel contrasting nature of #2 apparently led to increased relative accent on the object NPs and to a larger internal CR.

5.2.1.6) Paragraph context

Another way to set context for sentences is to place them in a paragraph, which provides a more complex context for a given sentence than does a simple question where the answer sentence merely replaces the Wh-word with another word or phrase (as in the Q/A context). As a result, the Fo effects in para-
graphs are correspondingly more difficult to isolate. Since the linguistic context for each sentence in a paragraph consists of all preceding sentences, any elements mentioned prior to a given sentence constitute old information. Thus, "the stress algorithm of Coker-Umeda" uses a rule that "in paragraph-length material . . . the first occurrence of a rare content word is generally stressed to a greater extent than later occurrences" (Lev instone, 1974:29). Coker & Umeda note: "The 'stress' on a given substantive word diminishes with repetition" (1971:138), and "A word receives stress in accordance to its importance to the overall message" (139). Their synthesis algorithm assigns "word prominence in proportion to the need for the word to be understood, i.e., in proportion to an estimate of the information load of the word" (Coker et al, 1973:295).

A second aspect of 'paragraph intonation' is that "in a series of sentences each of which ends in a low pitch, one usually detects an overall lowering at the end, signifying the closing of a particular topic of discourse" (Bolinger, 1970:110). In a paragraph, "the Fo peak[s] in later sentences rarely are as high as that of the first sentence" (Lea, 1973:29). Similarly, Mattingly notes that the initial value of Fo in a later clause "may be somewhat lower than at the beginning of the utterance" (1968:171). The generally lower Fo accents in paragraphs (especially in non-initial paragraph sentences) may be explained in this manner: the coherence of a paragraph discourse provides an extensive context with the result that later sentences in a paragraph apparently do not need as large Fo accents as earlier ones do, because as the paragraph progresses a general discourse environment
is set up in which the trend of the discussion has been conveyed to the listener.

5.2.1.6.1) Paragraph lowering

In the data of set F, Fo was usually lower in paragraph utterances (PUs) than in identical sentences spoken in isolation. Both the accent rises and Fo peaks attained in paragraphs were a few Hz less on the average. However, this general observation had many exceptions, often related to new/old word patterns, and accent levels varied throughout the course of a paragraph. The effect was more pronounced later in a given paragraph than earlier. In particular, few consistent differences were found in comparing the initial sentences of paragraphs with the same sentence spoken in isolation. For the 7 initial sentences in Tables 22-27, the accent peaks for the 3 speakers (JA, KS, and DO) were respectively -5, -2, and +5 Hz different in the paragraphs than in citation. Thus JA and KS exhibited a small decrease in accent peaks in the initial PUs, but DO apparently started most paragraphs with higher Fo levels (perhaps in a form of anticipation - with a 'burst of energy,' as it were).

Compared to an average decrease of only -1 in accent peaks for the initial PUs over citation utterances (CUs), the non-initial PUs averaged -6 lower than their corresponding context-less versions. The difference for DO alone was even more striking: +5 higher for initial paragraph peaks, but -8 lower for non-initial ones.
In short paragraphs (2-4 sentences), there was a tendency toward Fo levels decreasing with each sentence, with the lowest levels (relative to the CUs) in the last utterance of each paragraph: -13 for the last one, -5 for the next to last, -3 for the second from last, and no change for the first of a 4-sentence paragraph. The longer paragraphs (6 sentences) followed this trend, but with a slight variation: the last 2 sentences had peaks -7 lower than the citation versions, the middle 2 sentences had no change, and the first sentence had peaks +2 higher. However, the second sentence showed -7 lower peaks. It may be that, after a 'strong' initial start in uttering a long paragraph, the speaker drops his Fo off abruptly in the second sentence (after the topic is established), before settling into a 'normal' paragraph declining rate in the rest of the sentences.

In a comparison of paragraph and citation contexts, the initial sentences in each paragraph had the least variation, being only -1 lower in Fo peaks in paragraphs. In these utterances, the peak pattern varied little over the course of each utterance; for instance, the initial peak was only +1 higher in the paragraphs. In the non-initial utterances, however, the initial peak was -15 lower in the paragraph versions, compared to -7 lower for the second peak in each utterance (and -7 lower for the average of all the peaks in each utterance). Thus, it appeared that a major portion of the drop in Fo levels in non-initial PUs occurred in the lower initial peaks of each utterance.

The CUs and initial PUs appeared to start off at high initial levels, which then dropped off rapidly in each utterance to a more basic lower level; whereas non-initial PUs lacked this initial high starting level. This lack
of a high starting Fo peak was perhaps the most characteristic aspect of paragraph Fo.

5.2.1.6.2) New/old situations

Table 28 and Figs. 61-62 illustrate both the Fo effects of paragraph lowering and of the new/old situations that many paragraphs construct. For the second and final sentence of 2 different paragraphs ("When he got home, Joe boiled the noodles he'd bought"), the citation version (#1) had +8 and +17 higher Fo peaks than paragraph cases #2-3, respectively. The difference between the 2 comparisons is likely related to the amount of old information each PU contained. In #2, the prior PU was "Joe went to the store to buy some food," and in #3, "Joe went to the store to buy some noodles." Thus, in #2, only "Joe" was old in the second sentence, whereas in #3, both "Joe" and "noodles" were. As a result, while the other ASs had -6 lower peaks in paragraph case #2 than in #1, "Joe" had a greater decrease in accent (-10 less, -14 lower peak). Yet, #3 had even lower accents: except for the words "boiled" and "noodles," #3 had -6 lower peaks than #2. Compared against #2, #3 had increased accent on "boiled" (+5 more, +2 higher peak) and much decreased accent on "noodles" (-16 less rise accent, -31 lower peak, 22 less descent).

Since "noodles" was old in #3, it had decreased accent, and the resulting decreased competition and increased separation allowed larger accent on the nearby "boiled," which was a new word. The decreased competition in #2, as a result of "Joe" being old, can be related to a +3 increase in accent on the
ensuing "boiled" over case #1 (where all the content words were new). It appears that, in paragraphs, it is not just the old words that reduce in accent, but that an increase in the number of old words in an utterance (via context) results in a general decrease in accent levels. This observation, which is likely a major part of the paragraph Fo lowering effect, can be related to the -6 lower peaks (except on "boiled" and "noodles") in #3 than in #2; while the accent decrease on "noodles" can be attributed to its being old in #3 and new in #2, and the accent increase on "boiled" to a competition/separation effect, the overall lowering of Fo is not easily explained by a local phonetic effect.

In paragraph #4 ("Joe went to the library with his medical books. When he arrived at the library, Joe studied the medical books"), the content words "library," "Joe," and "medical books" were new in the first sentence and thus old in the second. In comparing the paragraph and citation versions of the first sentence (Table 25 and Figs. 63-64), "library" and "medical" had only slightly less accent in the paragraph (-6 less, -4 lower peak), due to the paragraph effect, while "Joe" had the same accent peak in both versions. In the second sentence (Table 29 and Figs. 64-65), where these words were old in the paragraph, but not in the citation version, each was considerably reduced in accent in the PU ("library": -10 less, -28 lower peak; "Joe": -9 less, -18 lower peak; "medical": -8 less, -25 lower peak). The average -9 loss in accent and -24 lower peak values contrasted with the lesser (-11) peak decrease on "arrived" and the increased accent on "studied" (+13 more, +6 higher peak) in the paragraph case; while "arrived" had some aspects of
old information (partially predictable from "went" in the first sentence), "studied," the only new word in the last clause of the paragraph, increased in accent, overcoming the paragraph effect, because of the decreased competition and increased separation.

In contrast, consider paragraph #7 ("Joe and Sue were going to the library. Joe brought his medical books, and Sue carried her biology books. When they arrived at the library, they studied the medical books"). In the first sentence (Table 26), the 4 content words had only -2 Hz lower peaks in the paragraph version. In the second sentence (Table 30 and Figs. 66-67), the old words ("Joe", "Sue") had -10 lower peaks, but the new words also had -11 lower peaks. In the third sentence (Table 31 and Figs. 67-68), "library" (an old word - repeated from the first sentence) had a -19 lower peak in the PU than in the CU, but "medical" (also 'old') had only a -9 lower peak and actually had a +8 larger accent than in the CU, while the new "studied" had no change in its accent peak (but had -13 less accent).

Thus the words "Joe" and "Sue" in the second sentence and "medical" in the third, although 'old', did not lose much more accent than the 'new' words did in the same PUs. Mere repetition of words in a discourse does not guarantee loss of accent on the later 'old' occurrences of the same words. Unlike "library" in the third sentence (which lost more heavily in accent), these other 'old' words did not constitute information predictable from the context. Since 2 particular persons ("Joe" and "Sue") and 2 types of books ("medical" and "biology") were mentioned in the paragraph, later occurrences
were accented in order to help distinguish between the 2 members of each set. If noise were to obscure the words "Joe" and "Sue" in the second sentence, or "medical" in the third, a listener would not be able to determine which had been spoken in those contexts, in the way that "library" could be anticipated in the third sentence, or the way that "Joe" and "medical" could be predicted in the second sentence in paragraph #4.

5.2.1.6.3) Multiple repetitions in a paragraph

There was a tendency for an accented word repeated several times in a paragraph to further decrease in accent with each occurrence. For example, the word "books" in paragraph #2 occurred 4 times (independently of the phrase "history books", which acted like a compound, with little accent on "books"). In the second sentence (Table 32), it had only a -1 lower peak in the paragraph version, but in the third sentence (Table 33), it averaged -11 lower, and in the last sentence (Table 34), -30 lower, than in the corresponding CUs. This tendency did not appear when the information was not predictable from context; "Jane" in this same paragraph, though occurring in each sentence, had at most -9 lower peak in the PU. With the introduction of "Mary" in the third sentence, "Jane" in that same sentence had a small increase in peak value, and the occurrence of "Jane" in the last sentence had only a -9 lower peak, since either "Jane" or "Mary" could have occurred at that point in the discourse.

Exemplifying the problem of obtaining a simple rule to relate new/old information in paragraphs to Fo accent are several words in paragraph #5.
In their first introduction into the paragraph, "sofa", "carpet", and "rugs" had lower accent peaks than in the corresponding CUs (-14, -7, and -5 lower, respectively). By contrast, "porch", "cloth", and "lamps," in their first occurrences, had higher peaks than in the CUs (+22, +13, and +6, respectively). Later occurrences from each set were more consistent, with the peaks on "sofa", "carpet", and "porch" averaging -9, -8, and -5 lower in the PUs, respectively.

Thus a simple 'reduce-accent-on-later-occurrences-in-paragraphs' rule does not suffice in all situations. The context of a paragraph apparently has a more complex effect on Fo accent patterns. In the first sentence of this paragraph, remodelling of a living room was mentioned. This often immediately brings to mind such items as sofas, carpets, and rugs, but not necessarily porches, cloths, and lamps. This might partially explain the decreased accent on the former and increased accent on the latter in their first occurrences in the paragraph. A more complete explanation probably would involve the immediate context of each of the words, as well as the overall paragraph environment. For example, "sofa" followed the word "moved" and "carpet" ensued "rolled up," which these word-combinations in each situation, while not forming 'compounds' or idiomatic expressions, do involve logical actions in remodelling a living room. In contrast, it does not necessarily follow that in carrying a carpet out, that one takes it to the porch. Thus it appears again that predictability in context is the strongest determinant of accent for a given word, and while a simple rule for Fo accents
regarding new and old words may suffice in a Q/A context, in a paragraph context a more complex algorithm is required.

As a further example, consider paragraph #3. A context of house painting is set up by the first sentence. The main information points of the second sentence (Table 40) are that one should use specific types of brushes and paint, viz., "bristle brushes" and "oil paint;" as a result, while the first content word in that sentence ("painter") had a -16 lower paragraph peak, "bristle" and "oil" were relatively increased in accent, compared to the citation case ("bristle": +16 more accent, -1 lower peak; "oil": no change in accent, -4 lower peak). The "if"-clause in the third sentence hypothesized not using a bristle brush (Table 41 and Fig. 69); since "not" is a M0, it was accented in the CU (+27 accent, 140 peak). In the paragraph version, the preceding sentence set a context of using a bristle brush; thus the negative aspect of the "if"-clause was of prime importance, and "not" increased in accent (+22 more, +11 higher peak) compared to the citation case. (Similarly, the second "not" (in the fifth sentence (Table 43)) had more accent in the PU (+12 more, +8 higher peak); the lesser increase in accent on this "not" is likely related to its being less the focal point of the sentence than "not" was in the third sentence.) Also, since the "bristle" attribute of the brushes used was the item being negated in this sentence, "bristle" did not lose much accent in this second occurrence (+3 more accent, -6 lower peak, than in the CU). Similarly, the second occurrence of "oil" (in the fourth sentence of the paragraph (Table 42)) was increased in accent relative to the CU (+9 more, +1 higher peak) because "oil"
had been established (via the paragraph context) as a specific type of paint to be used.

5.2.1.6.4) Modality operators in paragraphs

Twelve sentences from set D (Tables 2, 4-6, 10-11) were read by JA and KS embedded in 3 paragraphs (see Appendix), to observe how the Fo patterns of the MOs behaved in paragraph context. As above, the complex context of paragraphs made a consistent analysis of Fo difficult, but the following examples can be mentioned. In contexts where all content words except the modal were old (mentioned earlier in the paragraph): JA increased accent on "may" by +26 relative to the CU (PU #3, Fig. 28a, and Table 4:7 vs. 4:3); KS however left "may" unaccented, but gave "should" in 2:12 a heavy +46 accent (PU #10). On the other hand, in contexts discussing the possibility of boys studying their books (PU #8), the clause "Josephine might have studied her books" (11, #7) had low accent on the modal and verb, and high accent on "Josephine" (+8 higher peak, 37 more descent, than in the CU #3) (Fig. 31b).

In contexts where only the MOs quantifier and modal provided new information (PU #6-7, 11), substantial increases in their accents occurred over the citation versions (5:5-6, 8, 15). The 2 yes/no questions in these paragraphs (PU #2, 4) occurred in quotations (6, #4-5), and had overall higher Fo levels, especially at the start of the question (see 5.3.3.1). In sum, as far as can be determined with this limited set of PUs, the MOs behaved no differently in paragraphs than other words did.
5.2.2) Parallel units

Sentences with co-ordinated elements often exhibit a type of parallelism in the conjoined units; successive phrases frequently have similar syntactic structures, so that the words in parallel positions in these phrases observe a type of IC relationship. When two or more clauses or phrases are similarly structured in terms of syntactic units, word class types, and numbers of words, the speaker often wishes to draw comparisons between sentential elements which occupy the parallel positions. To help implement these comparisons, the speaker usually gives extra accent to one or more of these parallel elements (but more often to the first than the last of a set of parallel items). An example would be "The large bears are white, and the small bears are yellowish", where comparisons are made between "large/small" and "white/yellow." Although this parallel phenomenon occurs most often in conjoined structures, it can occur in simple sentences as well, e.g., "The big black cat ate the small white mouse," in which each adjective and noun in the subject has a parallel association with a word in the object.

To highlight the inherent contrast, elements in parallel usually receive larger Fo accents than other content words in the same utterance or similar utterances (Wode, 1972:1062; Hirst & Ginesy, 1974:53). Such a parallel relationship is sometimes called "contrastive," leading to CS (Rolinger, 1961b:115); however, unlike CS, which can occur anywhere in the sentence, the parallel situation is directly predictable from the sentence itself. For example, Lea et al refer to "a regular effect of co-ordination on stress patterns," in which parallel items get heavier accent (1975:35), and Halliday
uses a "system" of "Co-ordination Contrast" in his intonation description (1967:35).

5.2.2.1) Comparisons

Sentences involving comparison inherently exhibit parallel structure. Tables 46-47 show data for JA for such sentences: "The table was as long as the sofa (was (wide))" and "Fred bought more lobster than Joe sold (bluefish)," respectively. In 46, #1-2, "table" and "sofa" were the parallel items, and both were heavily accented ("table" with a high 184 initial peak; "sofa" with a -71 fall accent). However, the addition of the final word "was" in #2 apparently enhanced the parallel structure, as "table" and "sofa" averaged +23 higher peaks in #2 than #1. "Was" adds no information to the sentence (there is no difference in meaning between #1-2), but functions solely as a 'focus' element. In #3, the parallel relationship between "long" and "wide" appeared 'stronger' than that between "table" and "sofa," because the latter 2 lost and "long" gained accent, relative to #1-2. In #3, "long" ended the first clause with a -43 fall accent (33 more descent than in #1-2), because the 2 clauses were of similar size in #3 (but not in #1-2).

Table 47, #1-2 show the 2 ways JA uttered "Fred bought more lobster than Joe sold." The respective peak patterns were: 167-177-143-119-143 and 198-161-171-131-143. In #1, the parallel relationship between "bought" and "sold" was emphasized, with "bought" having a +16 higher peak than in #2, and the other peaks in the utterance (except "sold") averaging -26 lower. Conversely in #2, "Fred" and "Joe" received the parallel focus ("more lobster" also got
more accent in #2, but this is likely due to its being more separated from the focused items than in #1). In #3, there were parallel relationships between the subjects, verbs, and objects of the 2 clauses. Rather than accent each pair heavily, JA gave most accent to the nouns (again nouns were chosen over verbs for accent), with "lobster" and "Joe" averaging +22 more rise and 24 more fall accent (and +36 higher peaks), than in #1-2, while "sold" lost its +25 accent to a heavy +50 accent on "bluefish."

5.2.2.2) Semantic disambiguation

CS can be used in parallel structures to distinguish different meanings: e.g., "Bill kicked John, and then he kicked him" has 2 readings, in which the pronoun "he" refers to either "Bill" (the normal case) or "John" (CS case), and vice versa for "him" (Stockwell; 1971:44; Akmajian & Jackendoff, 1970: 124); i.e., the normal situation (with no accent on the function word pronouns) calls for parallel subjects and parallel objects; thus to convey the alternate reading, the speaker uses CS on both pronouns to override the assumed parallel relationships.

Such semantic disambiguation is illustrated in Table 48, where the same sentence ("She slapped him in the face, and then she hit the bastard") was uttered in 2 ways: with normal coreference between "him" and "bastard" (#1), or with "him" and "bastard" referring to different people (#2). The peak patterns of 123-131-95 and 123-118-122 show the big Fo differences that arise with a shift in reference. In #1, "bastard" was old information (with a mere +3 accent), while "hit," the sole new word in the second clause and in a
parallel relationship with "slapped", got a heavy +26 rise and -34 fall accent. In #2, "bastard" was a new word (with a big +22 accent and a peak +27 higher than in #1), while "hit", due to its proximity to "bastard", lost accent (-13 less rise accent, -13 lower peak, 13 less descent). The parallel structure of the verbs in #2 was suppressed in Fo by the need to override the assumed parallel relationship of "him" and "bastard."

Using vocoded speech and varying the location of an Fo accent obtrusion "above a straight base line" (1970:175), Nash attempted to disambiguate sentences of the type "NP_1 +V+ NP_2 +more than +NP_3", in which NP_3 could be in parallel comparison with either NP_1 or NP_2 (170). She concluded that "sentences cannot be completely disambiguated by the intonational surface structure," but that "definite tendencies" occur among listeners' perceptions: "If NP_1 is prominent, NP_3 is interpreted as subject. If NP_2 is prominent, NP_3 is interpreted as object. If neither is prominent, then ambiguity ... remains" (184). Thus the NP parallel to NP_3 should have an Fo prominence.

Cantrall has proposed a theory of "pitch concord," by which ambiguous pronominal coreferences can be discriminated, as in e.g., "John told Bill that Harry had broken his bike." Using "eight pitch levels," he suggests that three "unconjoined referent" NPs (such as "John," "Bill," and "Harry") would assume different pitch levels, and that "any mention of these referents thereafter will echo their unique pitch levels," e.g., the pronoun "his" in the above sentence would refer to the NP with the same pitch level (1969: 17). This extremely dubious theory has no empirical foundation. A more
likely possibility would be that most (but not all) pronominal situations lead to an 'unmarked' reading, with unaccented pronouns, in which the reference is to a parallel NP or to the nearest preceding NP (as in this case, to "Harry"), and to a 'marked' reading, in which the pronoun gets CS, to inform the listener that the 'normal' assumptions are to be overridden. This is a binary distinction only (certainly far from 8 levels), and would not allow for deciding between "John" or "Bill" in the CS case, as to which should be the referent. Furthermore, other situations remain in which not even this binary distinction is available, such as in "Helen thought that when she went to Paris, Mary was pregnant" (14); sentences like this have no 'unmarked' reading, and thus CS cannot be used to disambiguate.

5.2.2.3) Other Parallel Structures

The inherent contrast in a simple parallel structure, such as conjoined nouns in an NP, can lead to accent where it would not ordinarily occur. For instance, function words in parallel position receive accent, due to the contrastive nature of the structure, e.g., "between you and me" (Stockwell, 1971:34). Such an example occurred in Table 49 for JA ("_____ he and I will drive home _____," with the word "tomorrow" either sentence initial (#1) or final (#2)). In both #1-2, "he" had a big rise accent (to an average 175 peak) and "I" had a large fall accent (averaging -41). The big descent on "I" contrasted with the small -16 and -10 descents on the adjacent words "and" and "will," respectively. (Like most simple 2-content-word NPs (see 6.2.4), "he and I" here formed a P-unit.)

Schmerling claims that here, as for all uses of CS, "it is the signifi-
cance of the semantic relations involved which is correlated with the heavy stressing of the pronouns" (1974a:613). She further notes the use of "heavily stressed" interrogative pronouns in questions with more than one, and concludes that "such a question crucially involves contrasting semantic relations, in a way in which Wh-questions generally need not" (614). In a sentence with 3 such interrogative pronouns ("Who did what to whom?" - 50, #1) for JA, each of the pronouns got substantial accents ("who": 187 peak; "what": +33 accent, 162 peak; "whom": +38 accent, 159 peak).

5.2.3) Consecutive Word Repetition

Not all repeated words have reduced accent. A word may be repeated twice in succession for emphasis purposes, as in "Joe will never, never eat fish again" (51, #2 and Fig. 70). When compared against a similar sentence ("Joe will never actually eat fish again" - #1), the Fo effects of repetition appeared local in nature: only the Fo pattern on the adverbs differed. The peak pattern on "Joe will never actually . . ." was a typical 143-148-129 (the larger second peak indicative of larger accent on the negative than on the initial noun); whereas on "Joe will never, never . . .", it was 143-163-136. Thus when "never" was repeated, its first occurrence was heavily increased in accent over #1 (+25 more, +15 higher peak). JA (but not KS or DO) increased accent on the second "never" by having a -33 greater descent there than on "actually."

Thus repetition of the same word twice in succession for emphasis appeared to be accompanied by Fo changes leading to more accent on one or both of the
repeated words. Even though words were repeated here, such situations were clearly not simple cases of old information, since words in successive repetition cannot be anticipated or predicted from context.

5.2.4) Types of prepositional-phrases

5.2.4.1) Agentive versus manner prepositional-phrases

In set C, 7 pairs of passive sentences were recorded; each pair was identical except in the final PP: in case #1, the prepositional object was an animate agent and in #2, an inanimate object or concept. Since the syntactic structure was the same in each pair, systematic differences in Po could only come from the semantics of the PP being agentive (#1) or manner (#2).

In Table 52 ("The seeds were sown by the (farmer's son; riverside)"), the respective peak patterns were: 154-125-110-112 and 155-138-118. (Use of '(x; y)' in a sentence description means that 'x' occurred in that sentence location in #1 and 'y' in #2.) Following similar initial peaks on "seeds," the verb and object had bigger accents in #2 than #1 (+10 and +2 more accent, +13 and +8 higher peaks, respectively). Similarly, in Table 53 ("Joe was seldom driven by the (chauffer; sheep farm)"), the peak patterns were 140-144-126-107 and 140-135-124-114. Here, "Joe" and "driven" had similar accents, while "seldom" had more accent in #1 (+15 more, +9 higher peak) and the object had more accent in #2 (+8 more, +7 higher peak). In Table 54 ("The church bells had already been rung by (some boys; sunset)"), the peak patterns of 128-120-97-108 and 130-114-112 illustrate again similarity in
early peaks (on "already") and divergence late in the utterance: more accent on "rung" in #1 (+3 more, +6 higher peak). Thus the agentive PP (#1) in Tables 52-54 tended to have less accent than the manner PP (#2).

When the manner PP had the form of an idiomatic expression, as in Tables 55-56 ("The mile race was always run by the (boys; book)" and "The race was actually won by a (horse; nose)"), there was less of a tendency for the agentive PP to have the lesser accent. The peak patterns were 125-121-110-106 and 123-128-109-109 for Table 55, and 145-119-116-126 and 147-123-113-107 for Table 56, for #1-2 respectively. In Table 55, "always" and the object had more accent in #2 (+7 and +2 more accent, +7 and +3 higher peaks, respectively). But in Table 56, the object clearly had more accent in #1 (+20 more, +19 higher peak). Thus, "nose" in the expression "won by a ____" got less accent than "horse," and "book" in "run by the ____" had only slightly more accent than "boys" there.

When the agentive PP named a specific person, as in Tables 57-58 ("The merchandise was stolen by (Fred; fraud)" and "The research was done by (Neal; night)"), it tended to get more accent than the manner PP. The peak patterns were 146-123-118 and 147-123-113 for Table 57, and 152-111-119 and 151-112-106 for Table 58, for #1-2, respectively. Again little variance appeared in the non-final peaks, but the object peaks differed: "Fred" got more accent than "fraud" (+4 more, +5 higher peak), and "Neal" had more accent than "night" (+15 more, +13 higher peak).
In summary, manner PPs tended to get more accent than agentive PPs in similar passive sentences when the agent did not name a specific person. When the manner PP was an idiomatic expression, however, the distribution was less clear. Indeed, the underlying factor seems again to be predictability. The more predictable the prepositional object was, given the prior context in the sentence, the less accent it was likely to get. Specific names cannot be anticipated in citation utterances, but idioms often can.

5.2.4.2) Scope of modification

These patterns are further illustrated in Tables 59-64, which contain 6 pairs of active sentences, each pair identical except for the final prepositional object. In cases #1, the PP modified the verb; in #2, it could modify the preceding noun instead. In Tables 59-60 ("He had earlier boiled some water for (a while; his coffee)" and "The two sides fought a war over the (years; bridge)"), the peak patterns were 149-123-120-94 and 152-125-122-117 for Table 59, and 165-124-124-104 and 159-122-131-118 for Table 60, for #102, respectively. Thus, in each table, there is little variance in the peaks before the final peak, where "coffee" and "bridge" (#2) got much more accent than "while" and "years" (+15 and +13 more accent, +23 and +14 higher peaks, respectively).

In Tables 61-62 ("He quickly ate the small meal on his (way; plate)" and "We beat the team with (great effort; gray helmets)"), the peak patterns were 122-120-110 and 126-120-113 for Table 61, and 151-138-115-107 and 160-131-115-117 for Table 62, for #1-2, respectively. The Fo distinc-
tion is less clear here: the initial peaks (especially the peak on the NP preceding the PP) showed little variance between #1 and #2, and the final nouns in #2 had more accent than in #1 (+8 and +4 more accent, +3 and +10 higher peak, respectively), but the differences were greater in Tables 59-60. In Tables 63-64, the situation was reversed: the PP in #1 had more accent. The peak patterns were 141-123-122 and 148-131-114 for Table 63 ("He drank his coffee without (thinking; sugar)"), and 147-126-123 and 136-120-112 for Table 64 ("He found the way through (chance; town)"), for #1-2, respectively. The objects in #1 ("thinking," "chance") had more accent than those in #2 (+6 and +9 more accent, +8 and +11 higher peak).

Thus one cannot say that NP-modifying PPs get more accent than verb-modifying PPs. It would appear true in Tables 59-62, but is shown false in Tables 63-64. As above, predictability is the key. "Coffee without sugar," "way through town," "over the years," "for a while," and "on his way" all tend to be more common expressions than their counterparts above, and as a result received less accent. Non-idiomatic phrases, such as "great effort" vs. "gray helmets" in Table 62, showed little Fo difference in their initial words, but the second word in the less common "gray helmets" had a greater accent than "effort" in "great effort."

5.2.4.3) Prepositional phrases in paragraphs

At the end of set D, a short story of 3 paragraphs was read that included 9 of the citation sentences. Since the amount of semantic coherency and amount of repeated information was less in these paragraphs than
in the others described earlier (5.2.1.6), there was less of a tendency toward lower Fo in the PUs here. For example, in PU #2 & 7 (where all the words were new), the peaks differed by at most 5 Hz with the citation versions. However, certain new/old effects did occur. After "coffee" was mentioned in PU #2, the peaks in PU #3 ("... he drank his coffee without thinking") averaged -13 less than in the CU. Similarly, in PU #8, all the peaks except that on "Joe" were +5 higher in the PU, but "Joe" (having been mentioned several times in the story) had a -14 lower peak.

5.2.5) Summary

In context, the inherent accent of a word (as specified by its form-class) was modified. Essentially, the words least predictable in context received the heaviest accents. Thus, in paragraph and Q/A environments, repeat occurrences of words (providing old information) got decreased accent, allowing the remaining new words to increase in accent (via a decrease in competition and increase in separation). Simple anaphoric repetition was not sufficient for decreased accent, however; when the repeated word was from a set of mentioned words, it retained accent to help distinguish it from others in the set. References to supersets of previously-mentioned items had little accent, while subsets (which further specify the items) retained accent. Lexically-repeated words not involving actual anaphoric relations lost less accent than true old information words.

There was generally lower Fo in paragraphs, especially in the later sentences, which occur after several words and ideas have been introduced
into the discourse. Paragraphs provide complex contexts, however; overtly new words had less accent in paragraphs, probably because the paragraph establishes a framework in which new words are selected from a set narrower than used for citation sentences (i.e., 'new' words in paragraphs are more predictable than new words in citation). A major portion of the lower Fo in paragraphs occurred in the lower initial peaks in PUs.

Parallel structures, with related words in similar syntactic positions (e.g., in co-ordination or comparisons), tended to have increased accent. Inherently-contrastive, they led to accent even on function words. Words in parallel positions are often assumed to be related; to disambiguate anaphoric reference in these situations, CS can be used. Manner PPs had more accent than agentive PPs, except when the PP named a specific person. Scope of modification for PPs appeared unrelated to accent size; instead, the accents on PPs were greater for more specific, less predictable words, and less for idiomatic expressions.

Modifying words (e.g., adverbs) repeated in succession received increased accent, due to emphasis by repetition. Similar 'unnecessary' repetition (as occurred in "The table was as long as the sofa was" and "He bought a red car and a blue car") led to increased accent on the parallel items, relative to other words in the utterance. The propositional content of such sentences is unchanged by deletion or pronominalization of the optional words; they function solely as 'focussing' elements.
5.3) Word Order and Transformation Phenomena

5.3.1) Simple syntactic transformations

In his quest to convey textual information, the speaker has the option of altering the surface structure of most sentences. The possibility of changing word order and inserting/deleting certain function words allows him to highlight certain parts of the sentence, without altering the basic propositional content. When a speaker utters a sentence with a syntactic structure 'marked' in that it has undergone a syntactic transformation, the Fo contour often reflects the transformational changes in a systematic way. The most striking results were found in the focus and offset transformed utterances, while lesser Fo effects occurred in utterances with ellipsis and preposing.

5.3.1.1) Passive

In the passive transformation (e.g., "A farmer ate the carrot" → "The carrot was eaten by a farmer"), the original object is placed in initial, subject position and the original subject is placed in a final, positional phrase. Since the unmarked case of FSP has the newer information late in the sentence, the passive is a useful tool to place a low information object into initial, topic position and a high information subject into final, comment position (Hutchins, 1975:114; Hinds, 1975:88-90). "A passive construction is much more natural when the 'logical' subject is indefinite and the object definite" (Dahl, 1969:41), i.e., when the transformation would place new information late and old information early in the revised sentence.
Passive appeared to have more subtle effects in Fo than other transformations. Table 65 and Fig. 71 show Fo for the active sentence "Joseph had welcomed Susan" and the passive "Joseph was welcomed by Susan." The only consistent Fo effects across the 3 speakers (JA, KS, and DO) appeared to be the decreased accent peaks (~11 less) on the nouns in the passive case vs. the active case. It may be that the passive de-emphasized the surface subject in favor of the verb, whose accent remained essentially the same here. However, the PP agent cannot be said to be emphasized here, since it too lost accent (for 2 of the speakers).

5.3.1.2) Preposing

The preposing transformation also switches the locations of words. Two of the forms preposing takes are adverb preposing, as in "Never has Nicky eaten fish" (Table 66 and Fig. 72), or VP preposing, as in "Cooking the fish will be the master chef" (Table 67). In each case, the preposed phrase switches positions with the subject. The Fo patterns for these 2 transformed sentences were compared to those of 2 similar but untransformed sentences ("Nicky has never eaten fish" and "Cooking the fish will be the most fun," respectively).

Since the utterances in Table 66 contained the same linguistic content and were very similar phonetically, any consistent Fo differences should be related to the preposing. For all 3 speakers, the presence of accent on the 4 content words was mostly unchanged by the transformation, but changes in the degree of accent did occur. Adverb preposing apparently emphasized the
switched words ("Nicky" and "never") with increased accents, relative to the remaining words in the utterance. They averaged +18 more accent and +21 higher peaks in JA's speech, while Fo on "eaten fish" remained essentially unchanged. KS and DO, on the other hand, appeared to 'emphasize' the switched words by instead reducing accent on the other words; while the preposed word ("Never") did not gain in rise accent or peak height, DO did increase its accent with a larger descent and a CR, in contrast to a lesser post-peak fall in the non-preposed case.

While the utterances in Table 67 form a less-direct comparison for preposing, the overall Fo effects were similar to those above. The Fo peaks averaged +7 higher in the preposed versions (#2), across the 3 speakers. The respective rise and fall accents were also 7 Hz greater in #2. Since all the content words in these sentences were 'switched' words in #2, there were no words to compare against the ones with increased accent; so these results were less clear than those of Table 66, yet illustrated the same trends toward increased accents on the moved constituents.

Another form preposing can take is a movement of the full VP (except for one or more aux's) to initial position in a clause, as in "he will buy some" → "buy some he will" (Table 68). When preceded by the clause "George plans to buy some juice, and . . . ," the presence of preposing in the second clause had a modest Fo effect on the first clause: "George" had a -5 lower peak, while "buy" and "juice" increased in peak values by +6 and +8, respectively. Thus, the phrase "buy some" in #2 was apparently empha-
sized by its preposing, and the parallel accented words in the first clause ("buy," "juice") increased in relative accent as part of the preposing emphasis.

In the second clause, "will" was the only 'new' word, and it received the major accent of the clause in #1 (+40 rise accent, 139 peak, -42 fall accent), compared to a small accent on the verb "buy" (only a +9 accent to a 103 peak). This differs from the context-less situation, which would have larger accent on the verb (a content word) than on the aux (a function word). In #2 however, the preposed "buy" had increased accent (+34, 124 peak). The non-preposed "will," relegated to final position in the utterance, decreased in accent (+17, 117 peak), but still maintained more relative accent than "buy" did in #1; the peak drop-off there was -36, compared to only -7 in #2.

5.3.2) Focus transformations

Related to the concept of old vs. new information in sentences is the Fo phenomenon apparently caused by syntactic 'focus' transformations that result in 'focus shifting' of accent. From an underlying deep structure, with a presumed 'unmarked' or basic Fo contour, any sentence can undergo a number of syntactic transformations. Many of these transformations lead to changes in the Fo contour, but not simply a reordering of the Fo patterns to follow the word movements. Stockwell notes that "it is an intrinsic property of certain transformational rules that they assign to their output an intonation contour (i.e., . . . some contours are consequent upon the derivation
itself" (1971:26). Citing the example of topicalization, Bresnan claims: "many post-cyclic transformations, because they create so-called stylistic inversions, are closely connected with contrast and emphasis" (1971:277).

The focussing transformations re-arrange word order to call attention to certain words, at the expense of other words. The 'beneficiaries' of such transformations are usually those words desired to be semantically highlighted by the speaker. The typical Fo correlation of such transformations is one of Fo accent shift to the focussed word(s); this is manifested by larger Fo rises and peaks on the chosen word(s) and lower Fo rises and peaks on the remaining words in the sentence.

5.3.2.1) Definitions of Transformations

Unlike passive, whose functions are more diverse than simple emphasis shifting, there is a set of 4 similar transformations whose express purpose appears to be to 'focus' or emphasize a word or phrase in the sentence (underlined in the following examples), with the additional effect of de-emphasizing the remainder of the sentence. They are:

1) Clefting, which removes a syntactic constituent from a sentence, replacing it with a relative pronoun, and places it in a form of the phrase "It+be..." at the start of the sentence (e.g., "It was a farmer who was eating the carrot;" "It was the carrot that a farmer was eating").

2) Pseudo-clefting, which removes a phrase from a sentence, appends the word "what" to the rest of the sentence, and connects the 2 phrases with a form of the verb "be" (if a verb phrase is removed, a form of the
dummy aux "do" remains behind also) (e.g., "What a farmer was eating was
the carrot;" "Eating the carrot was what a farmer was doing").

3) 'Dummy-insertion,' which removes a NP from a sentence, leaving
behind a relative pronoun, appends a 'dummy' word (e.g., "one," "thing")
to the rest of the sentence, and connects the 2 phrases with a form of "be"
(e.g., "A farmer was the one who was eating the carrot;" "The thing that
a farmer was eating was the carrot").

4) 'There-insertion,' which transforms the verb group into a form
containing a version of "be" (if not present already), moves that "be"-form
to initial position, and places "There" in front of it (e.g., "There was a
farmer eating the carrot"), with the further option of leaving behind a
copy of the "be" word and inserting a relative pronoun before it (e.g.,
"There was a farmer who was eating the carrot"). Similar sentences can be
made using "this" instead of "there" as the added word ('this-insertion').

In each of these 4 transformations, the lexical item that is 'removed'
from the sentence is the element that receives added emphasis due to the
transformation. Each has the effect of calling the listener's attention to
the focussed word or phrase, while leaving the propositional content intact.
The option of using one of these transformations is one of the tools at the
speaker's disposal to accomplish the linguistic objective of altering a
sentence's FSP. To focus on a phrase, the speaker may: leave word order
alone and simply heavily accent the desired elements via intonation, use a
focus transformation, or use a combination of the two.
5.3.2.2) Results for one sentence

Cases #1-7 of Table 69 and Figs. 73-77 show Fo patterns for one group of sentences, each with the same 3 content words in the same sequence ("farmer," "eating," "carrot"), but varying in that each (except #1) had undergone a different syntactic transformation. Since the order of the 3 accented words was preserved throughout the group, Fo effects due to sentential positioning were minimized, and the Fo differences can be directly related to the transformations themselves. In the untransformed, unfocussed utterance of #1 ("A farmer was eating the carrot"), each of the 3 content words received accent: "farmer" (158 peak, -24 descent), "eating" (+23 accent, 125 peak), and "carrot" (+18 accent, 126 peak). In the clefted and 'there-inserted' versions of the original sentence, there was a small accent decrease on the unfocussed words: "eating" and "carrot" had respective peaks -17 and -11 lower than in the untransformed case (#1) in the clefted example (#2), and -8 and 0 lower in the 'there' example (#3). However, while the accent on "eating" decreased in #2-3 (-9 and -3 less, respectively), that on "carrot" increased (+2 and +12, respectively). Thus, on balance, a small decrease in accent on the unfocussed words can be related to these 2 transformations, with a greater decrease on the verb than on the object, and a greater decrease for clefting than the 'there' transformation.

The major effect of these transformations occurred on the focussed word ("farmer"): while the accent peaks for #1-3 were all high and varied little, the transformed cases in addition had large Fo descents. Compared to an
average -24 descent in #1, those in #2-3 were -55 and -50, respectively. These increased fall accents on "farmer," coupled with the decreased accents on the unfocussed words, had the net effect of emphasizing the focussed word in each utterance.

Similar observations can be made for the 'this-inserted' and 'dummy-inserted' utterances (69, #4-5). In both cases, while the peaks on "farmer" were -4 less than in #1, the peaks on "eating" and "carrot" were -14 and -11 lower, respectively. The descents on "farmer" were -47 and -39, larger than in #1, but smaller than for the other focus transformations.

In these focus transformations, certain words were added to the basic sentence: for clefting, there-insertion, and this-insertion, the transformed sentences began with "it," "there," and "this," respectively, as well as a form of the verb "be." These initial words, plus the focussed words, tended to form a syntactic phrase, which ended with a rapid Fo fall, as in a P-unit. With dummy-insertion however, the added words (e.g., a form of "be" + "the one") came after the focussed word, and the tendency for the focussed word to form a separate unit with a sharp final Fo fall-off was decreased, as indicated by the smaller descent in #5, compared to #2-4. Indeed, in 2 of the 5 readings by JA of the dummy-inserted sentences (69:6), the Fo descent on "farmer" was a mere -2 Hz. In these 2 utterances, the syntactic break occurred after the word "one" rather than after "farmer;" "one" had a -31 fall plus a +8 CR marking the boundary, as compared to having just a +18 rise in the other 3 examples of dummy-
insertion for JA. This apparent option to 'focus' on the word "one" rather than on the moved word "farmer" can be related to the inserted words' being added after the intended focus words (rather than before them, as in the other focus transformations); syntactic breaks marked with Fo falls are more likely to occur after several words than after just 1 or 2. Judging on a basis of this option and on the sizes of the descents on the focussed words, a scale of transformations with decreasing 'focus' effects would be: clefting, there-insertion, this-insertion, and dummy-insertion. The speaker's choice of which (if any) of these transformations to use in a particular situation is likely accordingly influenced by the degree to which he wishes to emphasize one phrase at the expense of other words in the utterance.

The pseudo-clefting example (#7) differed from the other transformed cases above in that "eating a carrot" was the intended focus, rather than "farmer." As was often the case when 2 or more lexical words were the potential objects of focus, one received most of the focus accent: "carrot" had +22 bigger peaks and +21 more accent than in #1, whereas "eating" had -6 lower peaks (again, the noun was chosen over the verb for accent).

Unlike the other transformations, pseudo-clefting may be said to act as a 'double-focussing' operation, in that "farmer," though not in the 'focussed' portion of the utterance, also increased in accent over #1 (+11 more, +16 higher peak). However, it may well be that most of this increase was due to an anticipation effect, since pseudo-clefting added
several function words to the sentence, thereby placing the initial content word at the head of a longer sentence.

Another manifestation of the focus on the phrase "eating a carrot" was that 2 of the speakers had CRs on the word "doing" (JA: +8; KS: +26), which indicated that the ensuing words were important. Such a CR did not occur in any of the other utterances in Table 69, either because the initial surface phrase was not long enough (as in #1) or because defocussed words followed the syntactic break (as in #2-6). In JA's speech, ". . . farmer was doing . . ." formed a P-unit, with "farmer" having no Fo descent, and the ensuing 2 USs averaging -22 each in Fo fall-off, before a -58 descent on "doing."

5.3.2.3) Altering the Focus Word

The rest of Table 69 and Figs. 78-83 concern utterances similar to those above, but with words of different syllable structure and stress location ("cow" and "gazelle") substituted for "farmer" as the focussed word. The Fo patterns for utterances with "cow" vs. "gazelle" showed no consistent differences (cases #8-10 vs. #11-13) other than on the focussed words themselves. With "cow," the unfocussed words lost accent (-2 less, -12 lower peaks), and similarly with "gazelle" (-1 less, -9 lower peaks).

On the focussed words themselves, "gazelle" averaged -8 less in peak and fall-off, and -9 less in rise accent than "cow" (most likely due to
the voicing difference). Whereas the Fo fall-off in "farmer" occurred mostly during the nasal (e.g., a -4 fall after the peak but during the AS, a -20 drop between nuclei, and a -15 fall in the US, in #1), on "cow" and "gazelle" (where the AS was word-final), the fall-off was within the AS itself (-37 in "cow" and -46 in "-zelle", in the untransformed cases). Thus the total fall-off was about the same, but was distributed differently depending upon the location of the AS within the word.

"Cow" exhibited increased accent in the dummy-inserted case #10 (+8 more accent, +7 higher peak) over #8; even greater accent increases occurred in the there-inserted and clefted cases (#9) (+15 more, +16 higher peaks). The fall-off in "cow" was approximately the same in the basic and dummy-inserted cases, but showed a -33 greater fall in the other focus cases. These results were very similar to those for "farmer."

For "gazelle" however, the descent only increased -6 in the cleft and there-inserted cases (#12), and decreased instead in the dummy-inserted case (#13). In addition, the accent on "gazelle" decreased in #12-13 (-10 less, -3 lower peaks), compared to the untransformed case #11. Since the unfocussed words following "gazelle" had -9 lower peaks, the focussed word had a net gain of +6 in peak values; however, it appears that the Fo effects with "gazelle" were less clear than those with "cow" and "farmer" above.
5.3.2.4) Clefting Various Phrases

Table 70 and Figs. 84-85 show results for the sentence "Joe delivered the meat to the market" (#1), 4 clefted versions (#2-5), and a version with the PP preposed (#6). In the untransformed case, the successive differentials in Fo peaks were -17, -10, and -15; thus Fo exhibited a gradual drop-off from peak to peak through the 4 accented content words, which is indicative of well-distributed accent. In contrast, the average successive differentials for the clefted cases here were -47, -1, and -8 (with little variation among the 4 different clefted versions). Once again, clefting appeared to focus on the first content word and cause Fo to drop heavily thereafter, so that the remaining peaks were at a much lower level.

Another way to view the Fo effect of clefting is to observe the Fo differences in the clefted word in each case. For "Joe," Fo in #1 (the untransformed case) attained a 153 peak (with only -8 Hz ensuing fall during the vowel), whereas in the clefted "Joe" Fo fell -50 from a 162 peak. For "meat," #1 had a +14 rise accent (130 peak), than a -9 fall, while the clefted "meat" had a 170 peak, then a -64 descent. For "market," #1 had a +20 accent (114 peak), then a -43 descent, whereas the clefted one had a 156 peak, then a -44 descent. The direct Fo comparisons here must, however, be compensated for sentential position. Thus, the comparison for "Joe" is most valid, since in comparing #1 with "It was Joe who delivered the meat to the market," the order of the content words was preserved. In the clefted case, "Joe" had a +20 bigger accent to a +9 higher peak, followed by a -50 greater fall, than in #1. The remaining accented words after "Joe"
were lower in accent in the clefted case: "delivered" (-23 lower peak), "meat" (-15 lower), and "market" (-19 lower).

A comparison in Table 70 of #4 with #5 shows 2 Fo differences resulting from clefting the full PP in #5 ("to the market"), rather than just the NP in #4 ("the market"). While the Fo peaks on the focussed word were virtually identical, there was -14 more descent in "market" when the PP was clefted. This greater fall-off (and hence clearer syntactic break marker) may be related to the more even distribution of syllables in #5; with the PP clefted, 6 syllables preceded the break and 7 followed (vs. 5 and 8 in #4).

The other difference was that Fo on the final accented word ("meat") varied depending on the presence of an ensuing "to": when "meat" was the final word in the utterance, Fo rose to a peak of 102 and then fell -29; whereas when "meat to" ended the utterance (i.e., when only the NP was clefted), Fo rose to 110, but fell only -2 during "meat"; instead Fo fell off before and during the final "to" (-9 prior drop, -23 fall during the vowel). Thus, Fo here appeared to drop rapidly at the end of the utterance only on the last word.

Utterances with a preposed PP showed much the same patterns as those with a clefted PP (cf. #5-6). However, one speaker (DO) had a much lower Fo peak on the focussed word in the preposed case (#6) than in #5, indicating the greater 'strength' of clefting as a focussing transformation for
his speech. The other 2 speakers exhibited another difference: they placed small CRs at the end of the preposed phrase, but not after any of the clefted phrases. This illustrates the balance of important words in the 2 cases: in #5, the unfocussed words represented de-emphasized information; whereas in #6, the words after the initial phrase were not predictable information, thus a CR was used to herald their advent (see later discussion on topicalization in 6.4).

5.3.2.5) Interchanging the Words in the Sentence

Table 71 and Figs. 86-87 show the results for transformed sentences in which the 3 content words appeared in the order: "eating," "carrot," and "farmer." "Eating the carrot was a farmer" (#1) was a version of the sentence in 56:1, but with a preposed verb phrase. Whereas the basic version ("A farmer was eating the carrot") had a peak pattern of 158-124-126, with a big differential between subject and verb, the preposed version had a 157-150-131 pattern; thus the 2 content words in the VP (whether preposed or not) seemed to have similar peak values, which argues for the syntactic coherence of a VP unit over a unit of subject and verb. Besides the variation in peak pattern, the major Fo difference here was that the preposed VP ended with a sharp -56 fall plus a +13 CR for JA and KS (as in 70:6, 12 above).

Comparing the dummy-inserted case (71, #2) with the preposed version finds increased accent on "farmer" (+7 more, +5 higher peak) and decreased accent on the other content words (-11 lower peak on "eating"; -3 less accent and -2 lower peak on "carrot"). These results relate to the focussing of "farmer" in final position, due to the dummy-insertion. As in
the preposed case, a CR preceded the syntactic break before "farmer" (a +12 CR, for JA and KS).

For the clefted "It was eating a carrot that the farmer was doing" and the pseudo-clefted "Eating a carrot is what the farmer was doing" (#3) (averaged because the patterns were similar) showed focus on the initial VP instead: "eating" had a peak +8 higher, and "carrot" had a +3 larger rise accent to a +11 higher peak, plus a 14 greater fall, than in the preposed case. The ensuing "farmer" was reduced in accent (-7 less, -15 lower peak); and there was no CR preceding "farmer," unlike in the other cases. The peak pattern here was 165-167-116 (showing the large drop-off on the de-emphasized "farmer"), compared to 146-149-136 in the dummy-inserted case (where the focus on the last accented word raised its peak and lowered the differential between prior peaks and that peak).

In a comparison of utterances with content words in the order: "carrot," "eaten," "farmer" (Table 72), the passive sentence ("A carrot was eaten by the farmer") had a peak pattern of 158-129-116 (#1), while the clefted and there-inserted sentences ("It was a carrot (that was) eaten by the farmer"; "There was a carrot eaten by the farmer") had one of 165-122-115 (#2). Thus, the typical sharp drop-off between the first 2 peaks (as in the passive case) was increased even further in the focussed utterances, due to the focus on the initial content word ("carrot"). Besides the +7 increase in "carrot"'s peak and the -7 decrease in "eaten"'s peak, there was a -21 greater fall accent on "carrot," marking the syntactic boundary ending the focussed
constituent.

In 2 of the 9 clefted utterances here (case #3 - 20:5, 8 - one each by KS and DO), Fo did not follow a pattern consistent with focus on "carrot": the peak pattern was 130-117-123, with the peak on "carrot" being -26 lower than in #2 for these 2 speakers. Apparently in these instances, "It was a carrot eaten by the farmer" was uttered, not as a focus sentence, but as a sentence with a relative NP clause.

Another example of dummy-insertion was the sentence "The thing eaten by the farmer was a carrot" (Table 73), which had a peak pattern of 168-162-142-135. Frequently, as here, the dummy word (e.g., "thing"), or 'semi-pronoun', receives accent; but there is usually little drop-off between the peak on such a dummy and the ensuing AS. The focus here was on the last word, which had a relatively high accent peak for final utterance position; in addition, the accent on "carrot" was +39, compared to only +18 on "eaten" and +32 on "farmer," both of which, occurring earlier in the utterance, ordinarily would have received larger accents (although part of the accent reduction on "eaten" was due to a separation effect, caused by the adjacent accented word "thing"). Finally, the late focussed word was again heralded by a CR at the preceding syntactic break (i.e., at the end of "farmer").

5.3.2.6) 'Indefinite' Focus and Clefting Clauses

There-insertion did not always lead to Fo focus effects; when the word in 'focus' position was an indefinite pronoun ("something"), the transfor-
mation appeared to raise Fo overall, but have no direct focussing effect. In Table 74 and Fig. 88, the sentence "Something keeps stealing the bait" had a peak pattern of 155-132-119, while for "There's something that keeps stealing the bait" it was 161-141-122, which represented an average +6 Hz raise overall. Clearly, the non-focussed words were not reduced in accent; in fact, their peaks increased instead. Thus, it may be that indefinite pronouns are inherently 'non-specific,' and do not allow the Fo effects of focus as nouns do.

The Fo effects of clefting occurred even when a full clause was clefted (Fig. 89). A comparison of the unclefted 2-clause sentence "Because Joe bought a new car, we went for a ride" (75, #1) with a clefted version "It was because Joe bought a new car that we went for a ride" (#2) found that in #2 the focussed clause ("because Joe bought a new car") gained accent (e.g., +25 more accent and +5 higher peak on "Joe"; +2 higher peak and 8 more fall accent on "car"), and that the unfocussed clause lost accent ("went": -6 lower peak; "ride": -11 lower peak). While the unfocussed clause was preceded by a CR in #2, it was small compared to the CR preceding the main clause in the unclefted #1 (+9 vs. +25), which indicated the differing importance of the second clause in the 2 cases: following the clefted, focus clause in #2, the second clause was less important; whereas following the subordinate clause in #1, the second clause was the main clause and contained important information.
5.3.2.7) Discussion

The concept of new vs. old information is important in discussing the Fo effects of focus transformations. Since the speaker effectively places emphasis on the focussed words and de-emphasizes the rest of the utterance by using a focus transformation, the focussed words can be viewed as 'new' words and the other content words as 'old' words in such transformed sentences. As above in sentences with actual new and old words, the focussed content words tend to receive increased accent, while the others lose accent.

Bolinger notes that sentences such as "The word I used was x" (dummy-insertion) or "What I said was x" (pseudo-clefting) use special "pitch prominence" to focus on the "x" word (1961b:114). Similarly, Atkinson notes that, with cleft sentences, "main stress occurs ... on the element in immediate post-copular position," e.g., "It was a car that John bought" (1973:219), even if a function word (such as a personal pronoun) occurs there (221); thus he claims that "cleft sentences involve emphatic rather than normal stress" (222). However, unlike CS, the focus accent here is directly predictable from the syntax.

In clefted sentences, there is "a non-normal distribution of given and new ... the thematic part ('It was X who/that') contains the new information and the non-thematic part (the 'which/that' clause itself) contains nothing but given information." Since a clefted sentence can be viewed as the answer to the question stated in the non-thematic part
(e.g., "Who ate the fish? It was the farmer who ate the fish.") (Hutchins, 1975:116-117), it is not surprising that the accent distribution in clefted sentences is similar to that found in the answers to questions. Similarly, Sgall et al have noted that "the relative clause in such sentences belongs to the contextually-bound [i.e., the 'given' or 'old'] part" and that such a variation in "'semantic' ordering" will be "marked by intonation" (1973:37, 287; also Lee, 1956:346).

In interpreting the linguistic effects of pseudo-clefting and dummy-insertion, Halliday treats such transformed sentences in terms of "equative" clauses, which have "three elements, a 'known,' an 'unknown,' and a relator" (i.e., a form of the verb "be") (1967a:12-13), where the focussed 'identifier' clause is the 'unknown' and the rest of the sentence provides the 'known' or 'identifying' clause (1967b:223-226). He considers clefting as having similar effects to these 2 transformations, but draws a distinction between clefting and there-insertion: "With 'it' the theme is defined (uniquely specified), with 'there' it is described (non-uniquely specified)" (1967b:236-238). This subtle difference may partially account for the lesser increased accent in there-inserted utterances than in the other focus transformed utterances.

Dahl treats sentences with there-insertion as existential sentences, where "in surface structure ... the existential operator is realized in some cases as 'there' and sometimes as zero" (i.e., nothing). "There often is a seemingly pleonastic 'there is' preceding indefinite pronouns" (1969:36);
e.g., the sentences "Someone eats fish" and "There is someone who eats fish" are virtually synonymous, which may account for the lack of focus effects in Table 74, where there-insertion was used in an attempt to focus on the word "something."

Preposing should probably be included among the focus transformations, due to its effects of altering word order and increasing the relative accent of the switched words. However, the Fo effects there were not as dramatic as those with the other focus transformations; so perhaps preposing should be grouped with passive as being operations which have some focussing Fo effects, but have the primary function of changing word order for the purpose of thematization or re-ordering the new/old information.

In a loose sense, the consecutive repetition of a word for apparent emphasis purposes can be viewed as a type of focus transformation. Although its Fo effects are local in scope, the insertion of a repeated word in succession with its first occurrence adds nothing to the propositional content of the sentence, but helps to focus the listener's attention on those words.

5.3.3) Type-of-clause effects

5.3.3.1) Parenthetical expressions and quotations

In speech, an utterance may contain a parenthetical clause or phrase (frequently marked in text by parentheses or dashes), in which the speaker uses his intonation to distinguish that expression from the rest of the
utterance as being secondary in importance to the main message. "The pitch level of the entire parenthesis is lowered, the volume is reduced, and the extremes are set off by pauses" and CRs (Bolinger, 1964b:25); "the accents continue to appear where they normally would, but in the parenthesis they are flattened somewhat" (26; Crystal, 1969b:264; Stockwell, 1971:43). Peck notes that "monotonic speech with a somewhat reduced speech power" is characteristic of "parenthetical remarks" (1969:44). A parenthetical expression invariably occurs in the middle of an utterance (Bolinger, 1970:110), because if it occurred initially, it would shed its role as less relevant than the rest of the utterance; occurring at the end of a sentence, it would be referred to as an 'afterthought.'

One distinction between parenthetical expressions and embedded clauses is the Fo pattern preceding each: a planned embedded clause usually is preceded by a CR, whereas the (often spontaneous) parenthetical unit is normally preceded by at most a sustained, level Fo. If the parenthetical expression occurs at the end of an utterance, as an 'afterthought,' no CR precedes it; instead, Fo usually falls below the BOR there, and the afterthought is uttered with reduced Fo, unless "it is an important afterthought," providing a major modification upon the sentence message, in which case it gets "its own accent," with non-lowered Fo (Bolinger, 1964b:24).

Vanderslice refers to parenthetical material as having "downshift" in Fo, and notes that quotations use "upshift," a type of raised Fo (1968:99); thus quotations have the opposite Fo effect from that of parentheses.
Tables 76-77 concern such sentences with quotes and parentheses ("Joe said, 'the house has termites,' before he walked out" and "Then Susan (who is Joe's sister) ran out of the house"). In cases #2, the sentences had the special punctuation, whereas in #1, they were missing (the quotes were deleted and the parentheses were replaced with commas). The presence of a quotation had significant Fo effects: the content words in the quotation had increased accent over #1 ("house": +34 more accent, +11 higher peak; "termites": +16 higher peak, 7 more fall accent). In addition, "said" was heavily de-accented in #2 (having a -68 prior descent, vs. only -9 in #1) and a +18 CR preceded the quotation (vs. no CR in #1). Thus, the use of "said" (a common quotation-introducer) led to a syntactic break before the raised Fo in the quotation.

On the other hand, the parenthesized clause in 77, #2 was read more as an offset, independent clause than as a parenthetical expression. The only significant Fo differences between using commas or parentheses was that the CRs marking the boundaries of the embedded clause were bigger in #2 (+57 vs. +28 preceding the clause, and +23 vs. +10 at the end of the clause). The accent patterns before, during, and after the embedded clause showed no changes with or without the parentheses. This implies that parenthesized clauses in text are not necessarily read as parenthetical expressions; the latter occur more frequently in spontaneous speech.

5.3.3.2) Embedding the Second Clause

The Fo contours in embedded and dependent clauses have reduced levels
similar to those in parenthetic expressions; however, the effects are usually less dramatic. Utterances containing more than 1 clause exhibit many Fo phenomena similar to those of single-clause utterances, but there are some differences. Figs. 90-93 exhibit Fo patterns for a set of sentences of the form "Bruce ____ said that Joseph ____ studied his books,"

where the blanks represent optional combinations from the group: "might," "not," "have," and "actually." Tables 78-75 give the averaged patterns for the first half and second half of these utterances, respectively.

Tables 80-82 illustrate Fo patterns for a set of pseudo-clefted sentences, which can be considered to consist of 3 clauses: a main clause connecting a sentential subject and a sentential complement. Each of these latter sentences contained one each of the MOs adverb ("actually"), negative ("not"), and modal ("might"), and was of the form: "What Bruce ____ said ____ that Joseph ____ studied his books." These 3 words were inserted into the blanks in several combinations along with supporting function words (e.g., "was," "been," "have"). Unless otherwise specified, the ensuing discussion utilizes averaged data from the 3 speakers (JA, KS and DO).

One distinguishing characteristic of multi-clause utterances is higher initial Fo levels. "Bruce" in initial position had average peaks of 167 in the 2-clause utterances and 168 in the 3-clause ones, compared to, say, 148 in the 1-clause utterances of Table 13. For JA and KS, the average peaks were 176 and 180, compared to 163 and 175 for the utterances with quantified subjects (Table 5) and Wh-words (Table 7), respectively, which had the highest peaks of the single-clause utterances. Thus, multi-clause utterances with a
simple noun in initial position had higher initial peaks than 1-clause utterances with a MO in initial position.

Unlike the high initial peaks of the MOs, the high initial peaks here were not followed by sharp drop-offs on the ensuing peaks. With the MOs as the initial accented words, the second peak was -46 lower; but with a noun as subject in the 2- and 3-clause cases, the second peak was only -17 lower, despite the initial peak's being higher in these multi-clause cases. Thus, this high initial peak was likely the result of an anticipation effect, whereas the high peaks on Wh-words and quantified subjects were more related to the IC nature of MOs.

In the 2-clause utterances, the average peak pattern for the accented words "Bruce - Joseph - studied" was 167-132-111, and for the 3-clause cases, 168-139-112. These represent relatively smooth drop-off rates; most of the drop-off occurred in the first clause, but "Joseph," at the head of the last clause, still remained well above the ensuing verb peak. The peak on "Joseph" in the 3-clause case was +7 higher than in the 2-clause case (despite the fact that 2 clauses preceded the former "Joseph," vs. only 1 in the latter) because the former were pseudo-clefted sentences with "Joseph" starting the focussed clause, which led to higher Fo than its position late in the utterance would ordinarily have dictated.

5.3.3.2.1) Modality operators

In these utterances, the MOs each received accent in virtually all
cases. In the 2-clause utterances, the accents on "might" and "actually" averaged +5 higher in the first clause than in the second. When it was the only MO in a clause, "actually" had the same +22 accent in either clause, but "might" had +10 more accent in the first clause than in the second (+15 vs. +5). Which clause contained "not" had little effect on the negative's accent, however: "might not" had respective accents of +6 and +21 in the first clause, and accents of +2 and +23 in the second. Placing all 3 MOs in one clause had a reducing effect on "not" in its middle position: "might not have actually" had accents of +12, +8, and +26 in the first clause, and of +7, +13, and +24 in the second clause; compared to the cases where each MO was by itself in a clause, this represented a loss of accent on "not" and a gain for "might" (but little change for "actually"). Thus, while "not" dominated "might" when they were adjacent without "actually" in the clause, the presence of the adverb led to a type of 'rhythm effect,' in which the middle MO's accent was reduced.

When "might have actually" was used in the verb group, the modal had little accent and the adverb had a very heavy one: +1 and +38 in the first clause, and +2 and +33 in the second. This represented a +14 increase in the adverb's accent due to the modal's presence, and a -8 decrease in the modal's accent due to the adverb's presence. This shift in accent is likely a linguistic consequence of the adverb's direct delimiting of the modal; "actually" following "might" performs an emphasis function, in which the speaker stresses the possibility of the situation in the prop-
osition. Inserting a negative, however, apparently takes some of the edge off the emphasis (see above), with the possibility of the proposition not being true becoming as important as the possibility itself. When "had not actually" was the aux-verb group, a simple separation effect was exhibited, with both the negative and adverb suffering losses in accent (of -5 and -4, respectively) due to their adjacent occurrences.

Another indication of the larger accent on the negative and adverb than on the modal was that, when immediately following the initial accented word in a clause, the peaks on the adverb and on the negative were only -14 lower than that initial peak, whereas the modal's peak was -26 lower. In addition, when "not" followed "might" in a clause, it averaged a +6 peak increase; similarly, "actually" averaged a +7 peak increase when following either "might" or "not."

5.3.3.2.2) Other Content Words

Somewhat surprisingly, the other content words in the 2-clause utterances showed little consistent variation depending on the positions of the MOs. "Joseph"'s +36 average accent varied mainly positionally: +7 larger when following 0 or 1 MO than 2 or 3, and +3 larger when preceding 2 or 3 MOs than only 0 or 1. The Fo peak on "Joseph" had more positional variation; when following 0, 1, 2, or 3 MOs in the first clause, its peak was 139, 131, 125, and 118, respectively; when preceding 0, 1, 2, or 3 MOs in the second clause, its peak was 128, 130, 136, and 145, respectively. Thus, the average peak on "Joseph" varied over a 21 Hz range (and the average accent
over a 7 Hz range) depending on its relative position in the utterance - more accent and higher peaks occurring earlier in the utterance.

Conversely, the other content words "Bruce" and "studied" showed little peak variation, since their sentence positions were relatively fixed. "Studied" averaged a +13 accent in the cases where "not" did not immediately precede it; with "not," it averaged only a +1 accent due to the lack of separation; in all the other cases, "have" or the USs of "actually" immediately preceded the verb, allowing it to have accent.

5.3.3.3) Pseudo-clefted sentences

In the 3-clause pseudo-clefted utterances, the last clause contained "not" in all 9 cases. When the other MOs ("might," "actually") were in the other clauses (i.e., with more separation between the MOs), the negative's accent averaged +30, whereas it was reduced to +21 when either "might" or "actually" was also present in the last clause, and to +18 when all 3 MOs were together in that clause. This pattern was similar to that for "not" in the 2-clause case above, except that here the accent was larger, because the final clause here was focussed due to the pseudo-clefting.

In comparable contexts in the 3 clauses, the adverb averaged a +32 accent, while the modal had +16. By themselves (i.e., with no other MOs present in the same clause), "might" and "actually" averaged +8 more accent in the second clause (i.e., in the main clause, which connected the sentential subject and sentential complement) than in the initial "What . . ."
-clause. This was likely due to the sharp Fo fall-off at the end of the first clause: before that break, Fo remained relatively high, with less room for upward Fo movement; whereas after the break, Fo was low enough to allow the larger accent obtrusion.

When the 3 MOs were spread out in the 3 clauses in the specific order "actually-might-not" (i.e., "What Bruce actually said might have been that Joseph had not studied his books"), each one averaged a +14 greater accent than in the other contexts where they were also well-separated. It was in this utterance that all 3 MOs stood out heavily in accent ("actually": +38, "might": +40, "not": +38), compared to, say, corresponding accents of +15, +23, and +26 for the MOs when they occurred in "What Bruce might have said was actually that Joseph had not studied his books." Thus, there apparently was some sort of semantic effect present in the former combination that led to each MO's being of prime importance in its respective clause.

As in the 2-clause case above, when "might have actually" occurred in one clause, the adverb had a very large accent (+46 here); however, unlike the former case, the modal here also had a substantial +18 accent (still -5 less than without the adverb present in the same clause, though). In the third clause, the relative 'weakness' of the modal was again exhibited; with more than 1 MO present, "actually" and "not" averaged +22 and +20 in respective accents, but "might" got only +3. Another indication was that, as the first accented word in an aux-verb group, "might" had a peak -18 less than the prior peak in each of the first 2 clauses (while "actually," in a
similar position, had a peak only -2 lower), and "might" had a -32 peak drop-off in the third clause (while "not" only had a -14 drop-off there). Further, when the adverb or negative was the second accented word in an aux-verb group, it had relative peak increases of +5 and +15, respectively, over the first peak in the group.

While the initial noun "Bruce" and the final verb "studied" showed no consistent Fo variation with the distribution of MOs in the rest of the utterance, "said" and "Joseph," being in the middle of the utterance, did exhibit positional variations in Fo, as "Joseph" did in the 2-clause case above. The peak on "said" at the end of the first clause was 150 after no MOs, 145 after 1 MO, and 135 after 2; similarly, it was 145 preceding 0 or 1 MO in the second clause, and 134 preceding 2 MOs there. Except when directly following the initial accented "Bruce," "said" received a primary accent (averaging +37): it was least (+31) in #9 (where each MO had very large accents) and greatest (+41) in #5. "Joseph," in the third clause, had peaks of 134, 142, and 146 when preceding 1, 2, and 3 MOs, respectively; in a similar fashion, the corresponding accents on "Joseph" were +40, +46, and +49.

The final verb averaged a +12 accent when the preceding word was "actually" (due to the 2 USs intervening) and a +15 accent when the prior word was "have," but had no accent when the preceding word was the accented "not."
In summary, the Fo accent patterns of multi-clause utterances differed from those of single-clause utterances only in relatively minor ways. The former had higher initial Fo values and hence wider Fo variation. Several semantic effects, due to the interaction of more than one M0, were noted, but not adequately interpreted. Pseudo-clefted utterances had larger accents on the final, focussed clause. The tendencies for larger accents earlier in an utterance (i.e., positional effects) and for larger accents when the ASs are well-separated were further illustrated here.

5.3.3.4) Other Variations with Embedded Clauses

In set E, the Fo effects of varying the embedding, matrix clause were further explored for JA's speech (Table 83). Using the same embedded clause "that Joseph might have (ADVERB) studied his books," the main clause was varied: "Bruce"+VERB in #1-4, "It is likely . . ." in #5-6, "... annoyed Sue" in #7-8, and "The thought . . . annoyed Sue" in #9-10. High initial peaks marked all examples here: 187 on "Joseph" when the embedded clause had the first accented word, and 195 on the first accented word of the main clause in the other cases (i.e., on "Bruce," "likely," or "thought").

In #1-4, the verb in the main clause was varied: "recognized" in #1, "feared" in #2, and "said" in #3-4. The monosyllabic "said" and "feared" had no accent rise, relying instead on a rapid Fo fall to mark accent, whereas the trisyllabic "recognized" had a +14 rise accent. Following roughly equivalent peaks on the initial "Bruce," "feared" showed greater accent than "said" (having 2 Hz less prior descent, and 16 Hz more fall on
the verb itself, than "said" did). The greater relative accent on the
verbs other than "said" was further illustrated by lower Fo values in the
embedded clause in #1-2 than in #3-4: "Joseph," "might," and the adverb
had -14, -7 and -3 lower peaks, respectively, after the 'stronger' verbs
than after "said." In an embedding context, "said" is a relatively fre-
quently-occurring verb, and is more likely to be predictable from context
than verbs like "feared" and "recognized," and hence carries a lower in-
formational load.

When the embedding clause was "It is likely . . ." (#5-6), the embedded
clause suffered an additional loss of accent due to the extraposition trans-
formation, which de-emphasized the back-shifted clause (see 6.4). Compared
to #1-4, the peaks on the embedded "Joseph," "might," adverb, and "studied"
were, respectively, +3 (higher), -4, -13, and -1 lower in #5-6, despite the
fact that only 1 content word (vs. 2 in #1-4) preceded the embedded clause
here. The extraposition appeared to affect the MOs mainly (e.g., the -15
less accent on the adverb), while having little Fo reduction of "Joseph" or
"studied," indicating again that the MOs, with large accents in neutral
contexts, tend to lose more accent than other content words in reduced-
accent situations.

Placing the embedded clause in a sentential subject (rather than a
complement, as in #1-6) had the typical positional effect on the embedded
clause of relatively higher Fo, since the main clause followed rather than
preceded. For example, compared to #1-4, the peaks on "Joseph," "might,"
the adverb, and "studied" were +18, +12, +11, and +8 higher, respectively, in #7-10. Prefacing the sentential subject with "The thought . . ." (as in #9-10) resulted in a +9 higher initial peak than in #7-8, a correspondingly -19 lower peak on "Joseph" (since it became the second peak in #9-10), and generally lower ensuing peaks as well. Except for the modal, the ensuing peaks were -8 lower in #9-10. This was likely more of a semantic effect, than a competition effect due to the extra accented word ("thought") in #9-10. Embedding a clause in the context "The thought . . ." (or, e.g., "The face . . .", etc.) embodies a type of presupposition, in which the clause represents information possibly at least partially-expected by the listener (even in citation-form utterances).

The local effect the presence of an adverb had on the Fo contour can be illustrated by comparing #6, 8, & 10 (with "actually") against #5, 7, & 9 (without it). Little consistent Fo variation occurred on the preceding and ensuing content words ("Joseph" and "studied"), but the preceding modal's accent was -7 less with than without the adverb. When the adverb "perhaps" was used in #4 (rather than "actually" or "occasionally," as in #3), the adverb's accent was slightly larger and the ensuing "studied" was de-accented (the latter effect due to the lack of separation between "perhaps" and "studied").

5.3.3.5) Matrix versus Embedded Clauses

Thus, Fo patterns on the same clause varied depending on whether it formed a single-clause utterance or formed part of a multi-clause utterance, and,
if the latter, whether it functioned as the matrix clause or as an embedded clause. Fo for the 1-clause utterance "That fish is tasty" (84, #1) was compared to cases where the clause "fish is tasty" was embedded in the 2 contexts "That ___ is true" (#2) and "It's true that ____" (#3) (Figs. 92-93). Although "that" preceded "fish" in each case, it had different syntactic functions and Fo patterns in the matrix and embedded cases. In #1, it served as a demonstrative adjective, receiving accent (+21, 147 peak); whereas in the embedded cases it was a conjunction, and as a function word, got little or no accent (as an utterance introducer in #2, it received a peak Fo of only 114). This difference was further indicated by the accent on the ensuing "fish": as part of an Adj+N NP in #1, "fish" averaged only +8 in rise accent, compared to +71 when "fish" was the sole word in the subject NP in #2.

Much of the accent increase of "fish" in #2 can be related to the addition of a second clause ("... is true") to the sentence. Even though the first clause was embedded in the sentence in #2, its accents were increased relative to the single-clause case: the peak patterns for #1 and #2 were 147-137 and 175-157-153 (on "(that) fish," "tasty," and "true"), respectively. This large increase in the initial Fo peak was likely an anticipation effect, in which the speaker 'prepared' for the second clause by raising his initial Fo. Notwithstanding this accent increase in the embedded clause, the main information in this utterance fell in the final, matrix clause. Fo noted this by having a high final peak on "true" (only -4 less than the second peak), as well as a large +63 accent, and a CR
(for JA and KS, averaging +14) at the boundary between the 2 clauses.

A direct comparison of matrix vs. embedded clauses is found in Table 85 and Figs. 96-98, where "Fred won the race, which surprised me" (#1) and "That Fred won the race surprised me" (#2) differed mainly in which clause was the matrix one. The initial peaks (on "Fred") were virtually the same, but the final peak (on "surprised") was -11 lower in #1 as part of the embedded clause, than in #2 as part of the main clause. In addition, the fall accent on the last word of the first clause was -12 greater in #1 (where it ended the main clause) than in #2 (where the main clause followed). This larger fall, which occurred from a slightly lower level than in #2, helped to signal more of a sense of 'finality' at the end of the main information clause than at the end of the embedded clause.

As illustrated in Tables 84-85, content words in main clauses tend to have larger Fo accents than those in embedded clauses. The likely reason is that, in 2-clause sentences, the matrix clause provides the major information points of the sentence, while the embedded clause yields background or peripheral information. As Langacker notes: "the main clause of a sentence is normally quite high in information content," and "the prominence of a constituent decreases in direct proportion to its degree of embedding" (1974:660). In the context of focus transformations, the choice by the speaker of which clause in which to place words he wishes to utter can be viewed as a focussing choice.
5.3.3.6) Independent versus Dependent Clauses

In set A, 21 sentences with an embedded clause modifying the subject were read by JA, KS and DK (Table 86). In #1, the sentence had an independent clause (e.g., "The older woman, who had been flown to the country, is driving to the city"), while in #2, it had a dependent embedded clause ("The older woman that had been flown to the country is driving to the city"), with the presence of commas noting the difference. There were small peak differences between #1-2 (on the last AS of the subject and on the first AS of the embedded clause, the peaks were +3 and +5 higher in #2, respectively). However, the major difference was the lack of a fall-rise to mark the clause boundary in #2: compared to a -43 fall and +21 CR on the subject in #1, there was only -10 fall and +4 CR in #2 (these represent averages: actually, only JA used a break in #2 and only on 2 of his 4 examples, whereas JA and KS both placed breaks there in all 8 examples of #1).

Similarly, when other independent embedded clauses (with commas) were used (e.g., ". . ., flown to the country, . . ." - #3; ". . ., flying to the country, . . ." - #4; ". . ., to be flown to the country, . . ." - #5; ". . ., whose son was flown to the country, . . ." - #6), strong Fo breaks marked the clause boundaries, with the subject getting a -38 fall and +19 CR. (In #6, with the added element of "whose son" in the embedded clause, the CR was a larger +25.) Few differences in the accent pattern occurred in #3-6; one variation was that, without any function words at the initial clause boundary in #3-4, the initial AS in the embedded clause had -10 less accent than in #1-2 and -5 less accent than in #5-6. Conversely, the peak
there was +5 higher than in #5-6.

Whereas the initial clause boundary had varying-sized Fo breaks, the second one was consistently marked with a -33 fall and +11 CR on the last AS of the embedded clause. JA averaged CRs about twice as large as KS and DK; DK placed breaks here, but not (with 2 exceptions) at the initial clause boundary (so the averages above would be adjusted higher for JA and KS, who did place breaks there, except in #2).

In sum, the major Fo effect caused by an embedded clause modifying the subject was that the second clause boundary had a moderately-sized fall+ rise break in all cases, but that the initial boundary was more selectively marked. 2 of the 3 speakers consistently gave strong Fo breaks to that boundary when the clause was independent, but not when dependent (without commas); whereas the third apparently considered the subject too short to warrant an Fo break at the first boundary (in virtually all cases). The few differences in accent patterns were related to separation effects.

5.3.4) Summary

The ordering of words within a sentence can be varied with syntactic transformations and with the use of embedded clauses. A major function of many sentence re-orderings is that of 'focussing' or emphasizing certain words at the expense of others. As a result, such transformations as clefting select a phrase for focus, and it gets increased accent while other content words in the utterance lose accent. This focus 'accent shift'
was present in there-inserted and dummy-inserted utterances, but was most
dramatic for clefted utterances. The focus effects remained the same
whether a word, phrase, or clause was clefted, and no matter which words
were focussed; however, the clefting of an indefinite pronoun led to no
accent shift.

When the focussed phrase was non-sentence-initial, a CR was used at
the syntactic boundary preceding it, but no CR appeared at the end of a
clefted phrase (since only de-focussed words followed). This dis-
tinction marked the difference between clefting and preposing: preposing
highlighted the switched words with bigger accents, but sometimes marked
the unswitched words also as remaining important, by using a CR after the
preposed phrase.

When the focussed phrase was moved to sentence-initial position and
some function words were inserted before it, the combination formed a
P-unit, with Fo exhibiting a sharp fall on the focussed word. Such P-units
were also formed by pseudo-clefting, a transformation which acted as a
'double-focus,' in that the non-focussed clause also retained accent. Words
within a simple VP (e.g., "eating a carrot") had similar Fo peak values and
often formed a P-unit.

Multi-clause utterances started with higher Fo levels (through anti-
cipation) than single-clause utterances, and the words in main clauses had
larger accents and higher Fo levels than those in embedded clauses. However,
embedded quotations had higher Fo levels than other embedded clauses. Internal embedded clauses had Fo breaks marking their boundaries, with the exception that dependent clauses after short subjects lacked breaks at their initial boundaries.

Other effects described above included: passive's tendency to emphasize the verb at the expense of the nouns, the tendency toward bigger breaks with a more even distribution of syllables on either side of the syntactic boundary, and the tendency for MOs to lose more accent than other content words in phonetically reduced-accent situations.
6) Syntactic effects:

6.1) Terminal patterns

6.1.1) Types of terminals

The terminal portion of the intonation contour has often been treated as the only linguistically-relevant aspect of intonation. Various studies have concluded that 'tentativeness' or 'inconclusiveness' is signaled by a rising or level terminal intonation, while a falling one indicates 'finality' or 'definiteness' (e.g., Cruttenden, 1970:187). Indeed, Bolinger claims that "the deeper the fall, the more conclusive; . . . with the rise, the steeper it is the more inconclusive it is" (1964b:28). In this manner, sentence categories such as yes/no questions (rising terminal) and statements (falling) are distinguished.

Chatman claims that "at the end of intonational phrases, . . . English . . . requires decisive rises or falls" (1966:28). Lea et al note that "intonation is the minimal differentiator between some declarations and questions" (1975:35), i.e., to distinguish statements from questions with no word order change or Wh-word. "Intonation goes down on the last stressed syllable and remains down to the end of the utterance" for statements, while "the intonation goes up [there] . . . and remains at a high level, or goes up, to the end" of yes/no questions (Pierce, 1966:68).

Öhman refers to "three typical patterns" for terminal Fo: "the terminative mode . . . characterized by a steeply falling end-contour that starts close to the end of the last stressed word of the utterance and . . ."
used in simple declarative sentences"; "the continuative mode has a level end-contour . . . to indicate that more phrases will follow" (i.e., the CR); and "the elicitive mode" with a "rising end-contour . . . used in questions and to express surprise" (1967:32). "The end-contour" starts "at the beginning of the syllable that immediately follows the last stressed syllable of the sentence. If the last syllable of the sentence is stressed the end-contour starts in its middle" (36). In the following, falling terminal contours (both terminative and continuative) are denoted as 'Tune A,' and rising ones as 'Tune B.'

Lieberman has postulated the existence of a binary feature + "Breath-Group" (+ BG), in which "the falling terminal [Fo] contour . . . apparently is a universal aspect of the unmarked breath-group" (-BG) (1967:104), while "a marked breath-group (+BG) . . . has a terminal not-falling Fo contour" (105); "yes/no questions in English are produced with +breath-groups," while "-breath-group . . . is used for short unemphasized declarative sentences" (1970:196).

Bolinger notes a study which found that questions in many languages had an "overall pitch level [that] was relatively high"; in particular, an English Wh-question, "like the statement, ordinarily ends in a fall, but nevertheless attains a higher average register than the statement" (1964a: 836). He also notes that in English, as in Chinese: "the rises are all questions or exclamatory protests; the falls are all statements or non-protesting exclamations" (838). In their analysis of Fo contours, Takefuta
et al. found that "statements and yes-no questions had similar patterns, but
questions had different melody patterns" (1972:1039). Vanderslice &
Ladefoged's rules similarly assign a terminally falling Fo to "statements,
WH-questions, and citation utterances" (1971:17). In his synthesis
algorithm, Rabiner used "a slope of 0.6 Hz/msec" for "a terminal rise of 60
Hz for a question" (1968:29).

In yes/no questions, Ohala claimed that there was either "a large rising
pitch at the end" or "a large rising pitch before the end and (a) thereafter
[Fo] remained high and possibly (b) had a slight rise at the end". "After
a single early rise" on the prominent syllable, "the pitch in a [yes/no]
question typically remains high until the end" (1970:101). Cohen & 't Hart
note that the terminal rise "need not occur in dominant words or even on
prominent syllables, as opposed to final falls," which must (1967:189). In
fact, the terminal rise usually occurs only on the last syllable in a
yes/no question, whether accented or not (Sag & Liberman, 1975:7). Indeed,
in their perceptual experiments with synthesized speech, Isachenko &
Schädlich found that, in yes/no questions, the final Fo "rising tone-
switch" occurs "only after the LAST ICTIC [i.e., accented] SYLLABLE" (1970:
35), and that in natural speech, the rise is not necessarily abrupt, "but
is usually spread over all the post-ictic syllables as a gradual rise" in
German (34). They note that if the Fo terminal rise starts on or before
(rather than after) the main stressed syllable, the utterance is "inter-
preted as 'unfinished'", and "can thus never be a sentence but only PART OF
A SENTENCE" (38). The question rises can also be distinguished from "stress-
related rises" (which "rise from low pitch to high pitch"), since they
"rise from wherever the pitch happens to be (usually fairly high) to a
still higher pitch" (Sag & Liberman, 1975:8).

6.1.2) Yes/no Questions

6.1.2.1) Yes/no questions with Modality Operators

The Fo contour in yes/no questions (Tune B) differed from that in
other utterances in 2 ways (Table 87 and Figs. 99-100): The middle of the
question utterance exhibited a lesser falling declination rate in Fo than
in Tune A, with Fo remaining above the BOR (even in the USs), and Fo rose
sharply on the last word in the question to a high level (usually the
highest in the utterance), rather than falling to the lowest level, as in
Tune A. For example, in JA's questions of 87:1-3, after the initial accent
rise, Fo never fell below 139 Hz, and rose to a final peak greater than
175 (compared to an initial peak of at most 170). Similarly, but less
clearly with respect to Fo remaining above the BOR, KS's Fo here remained
above 101 after the initial rise, and rose to a final peak greater than
139 (compared to an initial peak of at most 147). Thus, a major Fo
difference between JA and KS's patterns here was that of overall level,
JA's Fo being about +32 higher than KS's.

Probably because sharp falls signal 'finality,' none of the ASs here
had sharp fall accents; each AS had an Fo rise with at most a small
ensuing Fo fall. For example, "stud-" averaged a +8 rise accent, with only
a -1 ensuing descent; "Joe" and "boys" averaged +32 in rise accent, with
only a -7 descent. Only in the initial M0 in #2-3 was there a descent as great as -15 (following a rise accent of +23). Slightly sharper fall-offs did occur, however, on the USs: -18 on the first aux of #3, and -15 total on the 2 USs preceding the utterance-final "books," but these descents did not follow Fo rises and were not sufficiently large to mark relative accent.

Normal yes/no questions are marked by a switch in the order of the subject and the first word in the aux-verb group. The word shift appeared to have little effect on the Fo pattern: in initial position, the aux remained unaccented with a low lll peak (#1), the negative contraction was accented (+30, 159 peak (#2)), and so was the modal (+15 accent, 126 peak (#3)). The peak on the ensuing subject was the same in all 3 cases (145 Hz), but the accents were different: a +50 accent in #1 after the unaccented aux, +13 in #2 after the heavily accented contraction, and +33 after the lesser accented modal in #3. The variations in the amounts of accent can be explained by a competition/separation effect, and make clear that the negative contraction received more relative accent here than the modal. It may be that an uncontracted form of #2 (e.g., "Has Joe not ...?" or "Has not Joe ...?") is 'too formal' for normal English speech, that the contracted form is the 'unmarked' case, and that, as a result, the use of a contraction here is not meant to imply that the listener expects the negative aspect of the question; thus the full Fo accent of the negative is used, rather than the reduced form as on most contractions.
While all 3 cases had the same Fo peak on the subject, #1 (with the unaccented initial aux) had higher peaks on the verb and object than #2-3 (+4 higher on the verb; +9 higher on the object). This can likely be related to a competition effect: the extra MO in #2-3 tended to lower ensuing accents. Much of the important information of the questions in #2-3 was contained in the MO, which likely detracted from the accents on the other content words; but in #1, there was no MO, and thus no accent reduction.

6.1.2.2) Yes/no questions with Varied Phonetcs

To explore the differences caused by a yes/no question upon the normal accent pattern, several questions were recorded by JA in set H (Tables 88-95 and Figs. 101-105). In 88, #1-5, the question was "Would a small amount of X be sufficient?", with X being one of "wood," "paper," "carpeting," "delay," and "preparation," respectively. In each case, Fo rose sharply (+61) on the first content word ("small") to a 171 peak. After a small fall-off, "amount" had a small +6 rise accent to a 150 peak. Then Fo fell-off more sharply during "of" to a low of 127, whereupon Fo rose during the AS of X. For those X ending in an AS, Fo rose +45 to a 167 peak; for "paper" X, Fo had a +39 accent to a 167 peak on its US; for "carpeting" X, Fo had a +36 accent to a 162 peak on the AS, then Fo went up another +15 on the last US; for "preparation" X, Fo jumped up +27 to the first AS, fell-off -28, then had another accent (+33, 172 peak) on its second AS. Fo then fell-off to a low of 126 on "suf-", before a +32 accent on "-fi-". Finally, Fo jumped +25 and rose another +30 on the last US of
the question, to a high 212. Thus, unlike Tune A utterances, Fo here stayed above 126 after the first AS, exhibited rise accents on each AS (even to the point of having further small rises on USs after the big rise on the AS within a word), and had a sharp jump-rise on the final syllable to a very high level.

In Table 89, the question was "____ does William ____ intend ____ to resign his job ____?", where the adverb "seriously" occurred in one of positions #1-4. (These utterances, among 15 in set H, were recorded at 4 different speaking rates. Only the ones at the normal rate (the first in each group in the tables) are discussed here; see 7.4.4 for the others.) The location of "seriously" had little apparent effect on the Fo pattern, except in position #4, where it contained the question rise (being the final word, instead of "job"). As above, the first accented word ("William") had a large accent (+78, 171 peak); ensuing ASs had more limited accents ("intend": +8; "resign": +19; "job": +14); their respective peaks were 164, 147, and 143. Similarly, in positions #2-4, "seriously" had only +6 accent to a 148 peak. After the Fo rise on "William," the lowest Fo values were 129 Hz, occurring just before the ASs of "resign" and "job." The 'independence' of the final question rise from the rest of the Fo pattern was illustrated in "job": in each case, Fo had a prior jump to "job" and then Fo started to fall, before rising sharply. Tr was as if the normal contour was suddenly pre-empted by the need for a final rise on the last syllable.
6.1.2.3) Yes/no Questions with Embedded Clauses and Vocatives

In Table 90, #1 displays "Could we convene the meeting?" and #2 shows "Is there someplace closer that we could convene the meeting?". Comparing #1 with the second clause in #2, the patterns were the same but the Fo levels were +30 higher in #1, since the clause was an embedded one in #2 and a main clause in #1. Ending a yes/no question with an embedded clause led to a normal Tune B pattern on the initial, main clause (ending with a rise to 191 on "closer"), and then a sharp Fo fall-off to a low of 111 at the start of the embedded clause. After that, Fo remained above 120, with Fo executing another sharp rise (to 186) on the utterance-final "meeting."

Similarly, in 91, #1 ("Do you understand me when I speak German?") Fo had a sharp rise to 186 on "me" (ending the main clause), and there was another 'question rise' (to 211) on the final "German." However, Fo here showed no sharp fall-off between clauses (Fo fell to 143 over "when I"). In contrast, #3-4 ("Do you get exhausted, when you exercise?" - #3 without and #4 with the comma), had a pattern similar to 90, #2, in that Fo fell-off to low levels of 123 and 111, respectively, at the start of the second clause. (The presence of the comma apparently had little effect.) That the final question rise occurs only on the final syllable was illustrated here in that Fo fell during the second, unaccented syllable of "exercise."

When the embedded clause occurred first ("When I speak German, do you understand me?" - #2, and "When you exercise, do you get exhausted?" - #5), it observed a Tune A pattern (plus a CR), with the second, main
clause getting the Tune B shape. On the final word of the first clause, Fo fell from a 189 peak to a low 105, and had a big +40 CR to signal the upcoming second clause. Thus fall accents can occur in yes/no questions, but only before the main clause.

Single, offset words were placed after the main clause in Tables 92-93. In Table 92, #1 was "Are you ready?" and #2 added the vocative "Susan." In both cases, Fo rose to 150 on the first, accented syllable of "ready," but then Fo in "-y" differed: Fo rose in #1 sharply to 219, but only to 186 in #2. In #2, Fo fell during "Susan" to 162, before rising to 211. In 93, #2 ("Did you hear a horse, Winnie?"), Fo similarly exhibited a 'question rise' pattern on "horse" (to 176), fell on "Winnie" to 167, and then rose sharply to 220. Thus, when a vocative ended the yes/no questions, a 'suppressed' or 'reduced' question rise occurred on the final word in the main clause, before the final rise on the vocative. Showing that the effect was clearly related to vocatives, #1 ("Did you hear a horse whinny?") exhibited a prior jump+fall on "horse," rather than a rise, and the question rise occurred on the final verb.

6.1.2.4) Alternatives versus Examples

Lee distinguishes between yes/no questions with "examples" and "alternative" questions (1956:349; Adams, 1969:105): a question such as "Do you want A or B or C?" can be interpreted as "Do you want any of these?" (examples) or as "Which of these do you want?" (alternatives). The former receives a terminal rise, since it is a 'true' yes/no question; whereas the
latter gets a terminal fall, because it is really a Wh-question. 94, #1 shows an 'alternatives' question ("Are these red pencils yours or mine?"). It had a pattern similar to the question without "or mine" (#2), with "these," "red," and "pencils" all having rise accents, and Fo falling to its lowest level (123) at the start of "yours," before rising sharply to mark the question. The rise went to 192 in #2, but only to 180 in #1; in #1, Fo then fell-off to a low 98 Hz during "or mine." Thus, the alternative "or mine" reduced the size of the question rise, and 'appended' a Tune A fall to the Tune B pattern. In "Do you prefer coffee or soda? or something else?" (95, #1), "coffee" and "soda" provided 'examples' in the first portion of the question, with Fo exhibiting a +56 rise accent on "coffee" and "soda" ending with a +42 question rise; "or something else" provided an 'alternative,' causing Fo to fall-off after the Tune B pattern.

Hirst & Ginesy note that "Yes/No questions . . . will normally be realized with a rising tune"; "each time the speaker uses a falling tune with his [yes/no] question it is because he thinks he is giving the only alternative possible in the context," such as in a game of "20 Questions" (1974:51; Adams, 1969:106). These questions are simply 'alternatives' questions (ending with final falls), but with all but the last alternative 'deleted.' As Bolinger notes, yes/no "questions that use a terminal fall" "usually imply that the speaker already has part of the information he wants" (1970:114). Similarly, "rhetorical questions" had "falling pitch sequences " (Adams, 1969:105), that "when double [yes/no] questions linked by 'and' were asked, the first question was spoken with a rise and the
second with a fall" (106; Bolinger, 1964b:27).

6.1.3) Wh-questions

6.1.3.1) Wh-questions with Modality Operators

In contrast to yes/no questions, Wh-questions have the basic Tune A contour shape (Table 96 and Fig. 106). In "Which books has Joe been studying?" (#1), the peak pattern was 176-120-126; after the initial peak, Fo fell to a valley of 102 before the second peak, and after the final peak, to a low of 85 at the utterance-end. This particular pattern was quite similar to that of the utterances with quantified subjects (Table 5), in that the Wh-word (like the quantifier in initial position) received a heavy accent, with a large peak differential between the first 2 peaks. Indeed, inserting a negative or modal into the basic question provided only local variation in the Fo pattern.

For example, the insertion of "not" after the subject "Joe" (#2) raised the accent on "Joe" (+12 more, +11 higher peak), as well as adding the (+11) accented negative to the question, without altering the accent on the initial "Which books" or the final "studying." The replacement of the initial aux in #1 with a bisyllabic negative contraction in #3 raised the ensuing peaks by only +4 and +3 Hz, respectively, but reduced the accent on "Joe" (-9 less). The contraction itself got a +5 rise accent and a -23 fall accent (with a peak -38 lower than on the preceding Wh-word). Replacement of the contraction with a modal (#4) had little effect on the Fo pattern, outside of replacing the accented contraction with a word only
slightly accented (JA gave the modal only a +2 accent, and KS gave it no rise accent).

Thus, the Wh-word can be considered as heavily accented as the quantifier was above in initial position; the peak drop-off from the Wh-word to the next peak varied from -38 (with a negative contraction ensuing) to -56 (with an aux following). This heavy accent marks the Wh-word as having the Fo pattern of an IC word.

"Which books" formed a syntactic unit, with Fo rising sharply on the Wh-word and falling sharply on "books." "Books" had a -25 prior descent (indicating its relative lack of importance, in comparison with the Wh-word), but had a further descent of its own of -35 in #1-2, of -7 in #3, and of -31 in #4. Since, at the end of a P-unit, a larger descent is indicative of larger accent, "books" can be said to have more accent in #1-2, where the unaccented aux followed immediately, than in #3, where the accented contraction followed, or in #4, where the slightly-accented modal ensued.

The least accent on the subject (+9) occurred when it followed the accented contraction; after the unaccented aux in #1, the accent was greater (+18). The large +30 accent in #2, when "Joe" preceded "not," is possibly a result of the 'formality' of the sentence: "Which books has Joe not been studying?" is a 'marked' version of "Which books hasn't Joe been studying?". In most circumstances, one would use the latter; but when the negative was used in uncontracted form (#2), "Joe" increased in accent,
rather than decreasing, as would be expected with the separation effect. This pattern was followed by all 3 speakers, but also may be indicative of increased accent on a non-verbal preceding "not" (as in 5.1.2.3.1).

6.1.3.2) Other Wh-questions

In some Wh-questions, the Wh-word is non-initial (e.g., "Joe went to what bakery?" - 97, #1). This type of utterance still retains the Tune A shape, and the Wh-word still gets a major accent (+26 here). Another variation that can occur in Wh-questions is the addition of an extra word to the end of the question. Table 98 and Fig. 107 show 2 such additions: a vocative ("What's for dinner, Stan?" - #1) and an example ("What's for dinner - steak?" - #2). Both cases exhibit similar patterns, with similar peaks and sharp fall accents on "dinner." However, in #1, Fo only fell to 103 (vs. 80 in #2), and Fo remained in the BOR during 70% of "Stan," before sharply rising to 137 at the end. In #2, Fo jumped to 120 and then rose to 192, as in a yes/no question. Thus, just as an alternative adds a Tune A finish to a yes/no question, an 'example' adds a Tune B finish to a Wh-question. Vocatives, on the other hand, prevent Fo from falling below the BOR, and add a 'vocative rise' (of smaller size than a Tune B rise) to the end.

6.1.4) Other Combinations

In tag questions, Fo rose if "the speaker sought further information or clarification" from the listener, whereas Fo fell "if the agreement of the listener or his confirmation" was desired (Adams, 1969:104; Armagost, 1972:
Lee finds that "echo" questions (questions repeated by the original listener, due to surprise or misunderstanding) and "repeated" questions (those repeated by the first speaker, due to an unsatisfactory or surprising answer) both "have a rise from the first stressed syllable to the end" (1956:362), even if the question is not yes/no (Bolinger, 1964a:838; Halliday, 1967:43; Crystal, 1969b:273). In Adams' survey of Wh-questions, 89% had falling terminal F0, and those that did not were due to: "the addition of a vocative, a request for repetition, the echoing of a question . . . , the expression of diffidence . . . , or the expression of mild disbelief" (1969:105).

Gunter analyzed the intonations of two-person, two-line dialogues, and concluded that: a falling intonation in response to a question is an answer to that question, but in response to a statement either indicates: "recapitulation" or reaffirmation, if a word in the first statement is repeated and no new information occurs, or "contradiction," if a new word takes the place of another in the response (1972:205). A "high-rising" contour, in response to a Wh-question, indicates one possible answer (among others) (204) (e.g., 98, #2), while in response to a statement, it indicates "reclamation" (200) or an "echo question." A fall+rise contour in response to a statement indicates either: a correction with doubt, if a new word occurs in the response (e.g., "Nobody is in the house." "John?") or surprise, if a word is repeated (e.g., "John is in the house." "John?") (202). Gunter claims that these 3 F0 contours ("falling," "high-rising," and "falling-rising") (200), plus a fourth ("low-rising," which is a "sharply limited"
variant of the "falling" contour (205)), provide a sufficient inventory to account for "the role of intonation," viz., "the marking of relevance" (214). "Linguistic meaning lies only in the shape of the contour, and that meaning is the way the contour connects the response to the context" (206).

6.1.5) Perceptual Differences

In a series of experiments, Hadding and Studdert-Kennedy probed the perceptual relationships between Fo and linguistic features such as whether an utterance is a "statement" ("S") or a yes/no "question" ("Q"). They found that the S-category "was characterized by a lower Fo at the stress peak and a falling terminal glide," while the Q-category had a "relatively high Fo at the stress peak and a rising terminal glide." They postulated a third category, with the correlates of "a level terminal glide" and "a relatively even and moderately high overall Fo," which occurs "when the speaker was musing or talking to himself" (1974:7).

Using vocoded speech and sine waves, with synthetic Fo contours, they varied the "Fo values at the most important points of the contours (starting point, peak, turning point, and end point)" (8), and asked listeners to judge whether the terminal glide in Fo was "rising, falling, or level in pitch," and also to which of the 3 categories above that the utterance belonged (9). They found general confirmation of their 3 categories, but noted that listeners "have difficulty in separating the terminal glide from the immediately preceding section of the contour if that section displays a marked movement" from the Fo at the start of the contour (13), and in
particular that "listeners frequently judge a falling glide as rising and a rising glide as falling," and suggested that the judgments were "influenced by linguistic decisions" (1973:294). They found that "listeners make use of an entire contour, not simply of the terminal glide, in judging an utterance" (295), and suggested a principle of "perceptual reciprocity" in which "listeners . . . trade a high Fo at one point in the utterance for a high Fo elsewhere" (296), whereby an utterance, to be judged "Q", would require a high early Fo or a substantial terminal rise, but not necessarily both (304).

In distinguishing between "Q" and "S", they found that "the terminal glide is the single most powerful determinant" (305), but that the height of the "turning point" of Fo "takes linguistic effect indirectly by altering subjects' perceptions of the terminal glide" (309), while the value of the peak Fo has "a direct linguistic function," since its effect was "totally absent from the sine wave judgments," but "significantly present in the linguistic judgments" (310).

In experiments using synthesis-by-rule (not vocoded) speech, Majewski & Blasdell found that the presence of lexical content had little effect on "S" and "Q" judgments (1969:452), and that "the most prominent [Fo] factors that effected the listeners judgments were the absolute value of the endpoint, the value of the turning point, and interaction between them" (456) (i.e., not the terminal glide, as above). Confirming some of the above results, they did find that "as the frequency of the endpoint increases, the proba-
bility of a question response increases" (452): "values of the endpoint ranging from 170 to 190 Hz serve to cue the QUESTION decision for more than 75% of the stimuli," while the range from 70-100 Hz evokes STATEMENT responses (454). When the endpoint is in the middle, however, "the value of the turning point is most influential," with higher values leading to more "Q" judgments for American listeners (but the opposite for Polish subjects) (455). In a similar study, Uldall found that questions were marked by higher terminal Fo, independent of the initial contour pattern (1952:779).

6.1.6) Summary

Wh-questions had Fo contours similar to that of statements (Tune A), with the only significant difference that of larger accent on the interrogative Wh-word than on other content words. Yes/no questions had a Tune B pattern in which: all ASs after the start of the main clause were marked with rise accents, Fo remained above the BOR during that period, and Fo had a sharp 'question rise' on the last syllable in the utterance to a high level (usually the highest in the utterance). The combination of Fo staying at a higher level than in Tune A and Fo rising rapidly at the end conveys a request for a yes-or-no answer to the listener, and is used in normal yes/no questions, in 'repeat' and 'echo' questions (where the speaker requests verification that he understood the previous portion of conversation), and in Wh-questions ending in a suggested example. Besides Wh-questions, Tune A falls were used in 'yes/no questions' requiring other than yes/no answers: when asking for a choice of alternatives, in rhetorical questions,
and in questions where the speaker seeks confirmation or agreement.

The addition of an embedded clause or vocative to a yes/no question led to modification of the Tune B contour. An initial embedded clause simply had a normal Tune A contour plus CR, before the Tune B on the main clause. But a final embedded clause led to essentially 2 Tune B patterns, one on each clause, with Fo usually dropping close to the BOR at the clause boundary. A vocative at the end of a yes/no question led to a reduced question rise on the main clause and a further rise on the vocative. A vocative at the end of a Wh-question reduced the depth of the Tune A fall, and led to a small final rise. Subject-aux inversion had little effect on the accent pattern, with verbal and negative MOs still receiving accent in initial position.

These yes/no question patterns verified the observations of most authors above, although Ohala's observation that Fo remain high after the initial AS did not appear true here in all cases. While Fo often remained high, it did fall close to the BOR in several examples. The Tune B patterns exhibited evidence for the claims that high Fo, a terminal rise, and a high endpoint were important for an utterance to be perceived as a 'question.' That the Tune B pattern differed from Tune A in more than one location supports the likelihood that a substantial portion of the Fo contour is used to distinguish yes/no questions, rather than just the ends.
6.2) Delimitation of syntactic units

6.2.1) Segmenting

The major syntactic function of Fo appears to be one of segmenting an utterance into smaller phrasal units which usually correspond to syntactic entities. Lee notes that "intonation can be a connective device . . . [or] a disconnective," in which a sharp Fo fall would mark the end of a syntactic unit, while Fo remaining high would signal a continuing phrase (1956:359). Simply stated, phrases tend to start with rising Fo and end with falling Fo (Cowan, 1936). However, not all syntactic phrases in an utterance are so marked in Fo; the only certain 'grouping' Fo behavior is that of the initial phrase starting with rising Fo and the final one ending with falling Fo (in a Tune A contour). Utterance-internal boundaries may be marked by successive Fo gestures of fall+rise, but their presence depends upon many factors, such as the speaking rate, the length of the utterance, and whether the boundaries are 'major' ones.

To mark a syntactic unit, the rising and falling Fo movements must be large and rapid enough to clearly mark deviations from the normal Fo pattern. These rises and falls occur on the first and last ASs in the syntactic phrase, respectively, since ASs require Fo deviations independently of syntax. While the initial AS in a major syntactic unit is invariably noted with an Fo rise, Fo does not always remain high in preparation for an accented fall to end the unit. Often Fo falls to the BOR over a number of USs after the accent rise; only when the syntactic cohesion of a phrase is to be signaled does a 'hat' pattern of rise+level+fall occur. Thus while
phrase-initial ASs usually have rising Fo, phrase-final ones may receive raises and/or falls depending on whether the end of the units are to be specifically marked.

Lea & Kloker claim that "a decrease (of about 7% or more) in Fo usually occurred at the end of each major syntactic constituent, and an increase (of about 7% or more) in Fo occurred near the beginning of the following constituent" (1975:2). "Very large Fo changes accompany clause and sentence boundaries" (4); "just before pauses, Fo often drops very rapidly" (17). They found that 2.5 semitone rises in Fo were equivalent to 350 msec silences as indicators of syntactic boundaries (5). However, they conceded "that the detected boundary (at the bottom of the Fo valley) often does not coincide with the timing" of the actual syntactic boundary (5); rather, it "is usually located after the underlying syntactic boundary" (24).

Olive found "a difference in the slope of a [Fo] contour for a final and a non-final word in a phrase," and speculated that "this [final word] slope might be helping to communicate phrase boundaries" (1975:482). Isačenko & Schädlich note intonation's "segmenting function" (1970:42), and claim that "the change between high and low pitch is in itself sufficient to indicate the phrase boundaries" without an accompanying pause (43). In perceptual experiments, they found that two adjacent words with "no change from one pitch level to another at the boundary . . . are more closely associated than two which are separated by such a change" (44).
6.2.2) Fundamental Frequency Breaks

A syntactic constituent (such as an NP) often has a large Fo fall-off on its final lexical word, to help signal syntactic relationships to the listener. A large Fo occurs within a clause:

a) if the syntactic constituent is long enough (i.e., containing at least 2 content words);

b) if the boundary between adjacent syntactic constituents is ambiguous as to location, i.e., if the boundary may be located before or after a given element, then a fall-off occurs marking the actual place; or

c) if the syntactic boundary has been created by a syntactic transformation.

Utterance-internal boundaries, in addition to being marked by fall-rise patterns in Fo, sometimes have silence pauses (and CRs), which collectively constitute 'Fo breaks.' The size of the Fo gestures as well as the length of the pause are dependent on the 'strength' of the boundary in the surface structure.

The boundaries higher up in the surface structure tree are considered major syntactic boundaries, and received the largest breaks. In the corpora, virtually every non-final clause (embedded, as well as conjoined) was marked by an Fo break. A period of silence, as well as a CR, was a part of these breaks, except with dependent embedded clauses (i.e., NP-modifying clauses, whose presence in the sentence is non-optional on semantic grounds), where the silence period was often missing (but not the
The internal boundaries are those lower down in the surface tree, but still high enough to encompass several words in respective units on either side of the boundary, between such units as a long NP and its VP (e.g., "The large polar bears / live in the Arctic."), or an object NP (or PP) and a following, non-modifying PP (e.g., "The bears live on the ice / in the winter."). Breaks were not present between all NPs, PPs, VPs, etc.; only when the units to be separated were long enough did a break appear. Unlike clause breaks, which virtually always occurred, internal breaks were optional on the speaker's part. Breaks serve a structuring purpose in that they segment an utterance into smaller sections, which are easier for the listener to process. Such breaks are 'normal' at clause boundaries, but can occur somewhat arbitrarily inside clauses. If they occur, they do so at the major syntactic boundaries; but they may be deleted entirely, depending upon whether the speaker feels them necessary or not, and upon how precisely and/or rapidly he is speaking. Slow, precise speech is more likely to be marked by more structuring and breaks than fast, slurred speech.

Umeda finds that "speech prosody" can convey information to the listener about "juncture or boundary" conditions concerning "the grammatical and associative distance between" syntactic units (1975:8, 23), and that the "syntactic structure of the sentence . . . [is a] major factor . . . in determining the placement of boundaries" (4). In their synthesis-by-rule scheme, Flanagan et al assign syntactic "break probabilities" according to the surface structure of a sentence: they are "higher between subject and predi-
cate than between verb and object, ... relatively high between an intro-
ductive PP and the subject," and higher for "clause boundaries ... than
[for] any phrase boundary within the clause." "Any reverse order of occur-
rence among phrase categories indicates a clause boundary at the reverse
point ... . Punctuation marks require the highest probabilities of a
break" (1970:139; O'Connor, 1973:262). Low probabilities are given "to a
natural progression of subject-verb-object-dangling modifier, ... [with]
slightly higher pause potentials between long subject and verb and between
object and trailing modifier" (Coker et al, 1973:294).

The "potential for pause" is actually "a measure of how far 'up' the
[surface structure] tree diagram one has to go until all the formatives are
dominated by the same constituent; ... the words that are most intimately
related (in the constituent structure ...) are produced on the same
breath-group" (Atkinson, 1973:200). The actual placement of prosodic boun-
daries depends "on the length of the sentence, and on the speech rate ... .
Full stops have a falling pitch contour at the end. Commas indicate a pause
and a rising pitch contour, implying continuation. For deliberate speech
and for sentences of reasonable size, clause boundaries without punctuation
are terminated without pause and with rising pitch." (Flanagan et al, 1970:39).

Unlike the CK and pause, which occur immediately prior to and at the
boundary, respectively, the concommitant Fo accent fall and rise occur on
the ASs nearest to the boundary. These two types of Fo accent have been
noted by Bolinger: "Accent A: ... marked by a sharp drop in pitch after
the stressed syllable as against gradual movement or level pitch elsewhere,"
and "Accent B: ... marked by a jump to a higher pitch on the accented
syllable and with no sharp drop immediately afterward." Accent A is used as a "cut-off," with phrases "syntactically separate" or "logically separate," or in an iterative "assertiveness" (1957a:57), and "is favored on items that are new and contrastive, but avoided on items that are merely resumptive" (66; 1958a:145); whereas Accent B "suggests connectedness" or "incompleteness" (1957a:58). Bolinger also notes the use of "successive B accents" to mark ASs in yes/no questions; intervening USs "can be slanted downward" to allow room for the ensuing B accent rise (1965:174).

6.2.3) Syntactic Disambiguation

6.2.3.1) Disjuncture

Rabiner et al note that "disjunctures are often used to reflect the constituent structure of a sentence" (1969:93; O'Connor, 1973:263). Scholes defines "disjuncture" as being "vocal cues as to the proper parsing of the sentence," and notes that the "Fo contour . . ., the relative peak amplitude . . ., and . . . duration" are "three parameters of speech . . . available as cues for phrase structure" (1971:2). He notes that, in sentence pairs such as "the good flies quickly passed" and "the good flies quickly past," the "phonemic sequences are identical," but that "a disjuncture indicating the subject-predicate boundary location can disambiguate the pair" (1). In Table 99 and Fig. 108, "the good flies" in #1 exhibited syntactic coherence in that Fo fell sharply on "flies" (-46 descent), whereas in #2, a sharp -69 fall on "good" marked the end of the subject. The ends of the respective subjects were further noted with small CRs (+3 in #1, and +18 in #2). The
break was clearer in #2 because it was the 'marked' situation, with the subject-verb boundary coming after a very short subject. The disambiguation occurred entirely on "good flies"; the rest of the Fo pattern was the same in #1-2.

Similarly, 3 pairs of phonetically-identical sentences were recorded by JA (e.g., "The maid - en - countered her enemy" - Table 100), in which the word boundary was cued prosodically ("maiden countered" - #1, vs. "maid encountered" - #2). In Fo, the boundary was apparently marked by the location of the Fo descent after the peak in the first AS. The prior descent of "en-" in #2 was 23 more than in #1, whereas Fo fell 9 more during "-en" in #1 than in #2. Thus the sharper descent in #2 marked the word boundary there. However, #1 lacked any sharp fall; it may be that sharp falls only mark boundaries when an ambiguity might result.

Atkinson shows Fo plots for 2 different versions of the utterance "That shows what suffering men can create," in which a sharp Fo drop after "men" or "suffering" appears to cue the difference (1973:196, 355). Bolinger & Gerstman give data illustrating how Fo can disambiguate "light house keeper" (1957:88). In perceptual studies, Scholes found that "speakers do not tend to indicate the subject/predicate phrase boundary in simple sentences, ... [but they do for] the clause boundaries of complex sentences," and that "speakers vary significantly" in using disjuncture (1971:2). Klatt also notes that a NP-VP boundary "is not marked in the Fo contour" (1974:281), but speculates that Fo is often used "to indicate the ends of syntactic
units" (282).

One example of disambiguation via Fo came in Table 101 ("She gave the (boy plants to water; bean plants to charity)"). The peak patterns were 144-123-122-107 and 139-128-104-116, for #1-2, respectively. The syntactic boundary between "boy" and "plants" in #1 was marked in JA's speech by increased accent on "boy" (+4 more, +9 higher peak) and especially by 22 sharper descent on "boy" than "bean"; thus, the indirect object was marked by a sharp fall closing the syntactic unit. The other 2 speakers (KS and DK) chose to place greater accent on "bean" (+13 more, +13 higher peak) than on "boy" (which follows the typically smaller accents on indirect objects (see 5.2.5)). All 3 speakers gave "plants" greater accent in #1 (where it started a new phrase) (+17 more, +18 higher peak) than in #2 (where it formed part of the compound "bean plants"). Thus while the speakers differed on the need for a sharp disambiguating Fo fall on "boy," they all followed the typical compound pattern of accent on the first element in #2, while giving the separate "plants" in #1 a substantial accent. Incidentally, in "plants to water" (#1), "water" was de-accented (only +6 accent and 107 peak) compared to "charity" in #2 (+24 accent, 116 peak). Idiomatic phrases like "plants to water" act like compounds in de-accenting their second elements (Bresnan, 1971).

Cruttenden feels that "disambiguation by the use of intonation groupings is of relatively infrequent occurrence" (1970:184). As Atkinson notes: "In most cases, . . . the overall context in which the sentence occurs clears up
any possible ambiguity" (1973:195). However, "where there is no contextual cue . . . , the speaker . . . is sure to include sufficient cues in the acoustic signal to allow an unambiguous interpretation" (197). Further, in a synthesis-by-rule system, redundancies in Fo can only help the listener's perception.

6.2.3.2) Scope

6.2.3.2.1) Prepositional-phrase scope

Intonation has been claimed useful in disambiguating sentences with PPs, as to whether the PP is "adjectival" (modifies the direct object, say) or "adverbial" (modifies the verb) (Hartvigson, 1965:249; Isačenko & Schädlich, 1970:52; e.g., "I hit the man with the stick," Lieberman, 1967b: 318). The usual finding is that a prosodic ' juncture ' of some sort (usually including an Fo fall) exists before the adverbial PP, but not before an adjectival one (where, instead, a juncture might come between the verb and the object). Hartvigson claimed that this juncture can be described "in terms of the intonation of" the object NP, and found that an adverbial PP is usually preceded by a juncture and the lack of a juncture usually implies an ensuing adjectival PP, but that there were many exceptions (1965: 249). Similarly, the bracketing in an NP-PP-PP sequence can be signalled by intonation (Lea et al, 1975:35).

Such a sentence with 2 PPs was the topic of Table 102 ("Earl struck the man on the (leg; deck) with (his fist; the scar)"). In #1, both PPs ("on the leg," "with his fist") modified the verb, whereas in #2, the
second PP modified the first, which modified the verb ("on the leg with the scar"). This difference led to a sharp -55 descent and +28 CR on "man" in #2 (vs. a -5 descent and no CR in #1), to help signal that the ensuing words formed a separate unit. In addition, "leg" had a big -48 descent in #1, to mark a break there. In #3-4, "man on the deck" formed a P-unit (with a small -5 descent on "man," vs. a big -30 descent on "deck"). Also, there was more descent on "struck" and +7 more accent on the ensuing "man," than in #1-2, to help signal that the upcoming phrase formed a unit. That the final PP in #3 ("with his fist") modified "struck," while in #4 "with the scar" modified "man," had little Fo effect; apparently Fo only marked immediate scope here; and once a PP modified other than the preceding phrase, no other Fo difference occurred.

6.2.3.2.2) Co-ordination and Clausal Scope

The scope of conjoined words can often be distinguished via Fo. In Table 103, "Steve or Sam and Joe will be coming" had different Fo patterns depending on whether Steve or Sam were to accompany Joe (#1), or whether Steve might go by himself (#2). In #1, "Steve or Sam" formed a P-unit, with a big +33 CR at the end, and "Joe" had its own SC (also with a +ll CR at the end). In #2, "Sam and Joe" formed a P-unit, and "Steve" had a descent 59 larger than in #1 (marking the break after it). Thus co-ordinates can be disambiguated in Fo with the formation of P-units on the closely-associated words and with Fo breaks between the P-units.

Intonation can also distinguish two meanings of sentences with subordinate
clauses like "Please wire if I am to come" (Daneš, 1960:50), where the presence of a juncture after "wire" signals the disconnectedness of the two clauses (and the meaning is the same as if the two clauses were reversed in order), whereas lack of a juncture would not allow such a clause switch. Nickel treats this distinction as involving the number of "rhemes" a sentence has: "In a descriptive relative clause there are usually two rhemes," while a sentence with a restrictive clause has only one; he then suggests that "every sentence can have only one rhematized constituent unless there is a sentence pause between the two clauses in question (1970:674).

For example, in Table 104 ("if I'm still around __1__ when you hear from him __2__ let me know"), the presence of a comma at either position #1 or #2 can help disambiguate the scope of the "if" and "when" clauses. In #1, the first clause ended with a +41 CR (vs. no CR in #2), while in #2, the second clause ended in a +28 CR (vs. a +16 CR in #1). In addition, while the initial peaks of the first 2 clauses were within 5 Hz of each other, the final peaks varied: "around" having a +18 higher peak in #2, and "him" having a +22 higher peak in #1; higher peaks thus occurred without the comma breaks, i.e., the lack of an ensuing Fo fall kept Fo high.

6.2.3.2.3) Adverb scope

Crystal notes that placement of an Fo fall can cue "the distinction between different uses of an adverb" (1969b:264), such as in "He speaks English naturally" (105, #1-2 and Fig. 109): an Fo fall on "English" signaling the end of a unit (the main sentence), followed by a rise+fall on
"naturally" marks a break between the two words and treats the adverb as an "afterthought" (#1); whereas the lack of a sharp fall on "English," plus a sharp fall on "naturally," signals the sentence as one unit (#2) (Bolinger, 1972b:156). (Pope claims that such adverbs retain their intonation patterns even if the rest of the sentence is elided (1971:69), and thus argues that "intonation assignment" must precede "some syntactic deletion" rules (71).) A third way to utter this sentence used "naturally" as a sentential adverb meaning "of course" (#3). As in #1, there was a sharp break at the end of the main clause, but Fo did not rise from the BOR at the start of "naturally" in #3; instead, it rose sharply to 150, only on the final US (in a manner similar to a final vocative rise).

The Fo effects of adverb scope (Daneš, 1967:511) are illustrated in Table 106 and Figs. 110-112. The basic sentence was "John cooked the fish," with one of the adverbs "also," "only," and "even" inserted before or after "John" or "the fish." Adv+"John" and "John"+Adv formed the subjects in #1-2 and #3-4, respectively. These utterances had peak patterns of 151-143-112-109 and 145-141-108-105, respectively. Thus, there was a sharp peak drop-off marking the NP-VP boundary in #1-4. In contrast, #5-6, in which the adverb formed part of the VP, had a pattern of 137-136-127-129. Very little peak drop-off was exhibited. Indeed, this Fo difference can be used to disambiguate the 2 readings of sentences in #3-6 (e.g., "John only cooked the fish"). When the adverb modified the subject, there was a major break between the adverb and "cooked": a -33 peak drop-off and a -43 descent on the adverb. In contrast, when modifying the verb, the adverb had
only a -12 descent, and the peak differential was only -9. Thus the scope of the adverb and the location of the NP-VP boundary was heavily cued in Fo. A sharp Fo fall on the adverb closed the 2-word subject; while lack of a big fall let the adverb open the predicate.

Similarly, in #1-2, where Adv+"John" formed the subject, there was a sharp -46 descent on "John," with a resulting -31 peak differential. The peak patterns in #7-8 and #9-10 were 147-139-139-134 and 145-134-135-120, respectively. Thus, when "John" by itself was the subject, the first peak differential was at most -11; with the adverb, it was at least -31. Another correlate of the big syntactic break in #1-4 was that the first 2 peaks (before the break) were +11 and +6 higher than in #5-6, and that the last 2 peaks (after the break) were -17 and -22 lower.

In #7-8, the adverb came after the verb and before "fish," and there was little peak drop-off throughout the utterance; in #9-10 however, the adverb after "fish" suffered a -15 peak drop-off. These adverbs can be considered special in that they usually 'quantify' or 'scope' specific parts of the proposition (e.g., "John" in #1-4, "cooked the fish" in #5-6, and "the fish" in #7-8). In that function, there was little Fo peak differential between the adverb and its quantified elements; they tended to form P-units. However, in #9-10, the adverb occurred after the proposition, too late to 'focus' on any element there, and its effect was reduced (with a lower Fo).
In examining the individual Fo patterns of the 3 adverbs, "also" and
"only" behaved similarly, while "even" showed some deviations. For
example, in utterance-initial position, "even" led to bigger Fo effects
than "only" (the peaks on "Even John" were +6 higher than on "Only John," with no difference in ensuing peaks). In fact, "John" averaged +7 higher
peaks adjacent to "even" than next to "also" or "only" in #1-6. Thus,
"even" was a 'stronger' quantifying adverb in that it focussed more heavily
on its quantified elements.

6.2.3.3) Vocatives and Appositives

Fo can be used to mark "the distinction between end-placed vocative and
apposition" (e.g., in "It's the baker, Mr. Jones" (107, #1-2), or "John has
a brother, Robert"(#3-4)), or "between apposition and list" (e.g., in "The
two; three) people in the house are Joe, my son, and his wife" (108, #1-2))
(Crystal, 1969b:264) In Table 107, the final phrase in #1 & 3 was read as
an appositive, and in #2 & 4 as a vocative (Fig. 113). As a result, the
final word in the main clause had a -7 lower peak and a +19 CR in #1 & 3,
and the final phrase had a +46 higher peak than in #2 & 4. Further, the
appositive ended in a fall, while the vocative ended with a +24 rise to a
110 level. Thus, the appositives followed the 'normal' Tune A pattern, and
were signaled here by a prior CR; with the vocatives, Fo fell -12 lower
at the end of the clause (instead of having a CR) than in #1 & 3, and
ended the utterance neither with a question rise or a fall, but rather with
what might be called a 'vocative rise' (small, and to a relatively low level).
In Table 108, #1 presented a list of 3 people ("Joe, my son, and his wife"), whereas #2 utilized apposition in that "Joe" = "my son." In #1, a small +10 CR occurred at the end of "house," signaling the upcoming list, and large +45 CRs appeared at the ends of "Joe" and "son." In contrast, the only CR in #2 was a smaller +23 CR on "son." "Joe" in #2 had a -82 descent (vs. -8 in #1) and no ensuing CR. Thus apposition here was marked by a sharp descent and lack of CR at the boundary between the related words. The appositive here lacked a prior CR (unlike the cases above) since the lack of a CR was a prime indicator that the 3 phrases did not form a simple list.

When a vocative occurred sentence-medially ("You, my friend, will have to leave immediately" - 109, #2), there was: a sharp descent on "You," low Fo on "my friend," and a +13 vocative rise. Compared to "My friend will have to leave immediately" (#1), the later peaks in the utterance were -28 lower after the vocative, likely due to the sharp fall-off on the word preceding the vocative. In sum, both vocatives and appositives had large prior descents, but, unlike appositives, the vocative was also marked by a 'vocative rise' and always lacked a prior CR. Similarly, Fo can be used to distinguish types of embedded clauses: "appositive" or independent clauses will often be marked by prosodic breaks (including CRs) at their terminals, whereas "restrictive" or dependent clauses will lack such markings (Lee, 1956:351; Halliday, 1967:35; Crystal, 1969b:264) (see 5.3.3.6).
6.2.4) Phonological Units

One effect syntactic structure has on the Fo pattern of an utterance is that of delimiting certain sets of words into 'phonological units' (P-units). These units grouped by Fo invariably align with major constituents in the syntactic structure, in that words closely related in the surface structure occur within the same P-unit. These P-units have Fo shapes coarsely-describable as rise + relatively level + fall movements, with the rise and fall occurring on the initial and final ASs, respectively, of each unit. The pattern between the initial rise and final fall of each unit is more accurately described as a very-slowly-falling pattern. However, when more than 2 ASs appeared in a P-unit, the medial Fo pattern contained rises and falls in addition to those on the exterior ASs. What distinguished the P-unit in these cases was that the initial rise and final fall were large compared to other Fo rises and falls, and that Fo remained above the BOR throughout the unit.

Maeda has assigned the term "phonetic group" to "a group of words chunked by the combination of" a sharp Fo rise, a stretch of gradually falling Fo, and then a sharp Fo drop (1974:202). This is the "hat pattern," to which Collier attributes "the possibility to integrate under one 'arc of tension' those lexical items that stand in a close syntactic or semantic relationship" (1972:127). This key middle portion has been called a "sustention of tone" occurring "in medial positions in the sense group" on "unstressed parts" of the utterance (Adams, 1969:103, 108). However, the use of this hat pattern "is not obligatory" and in Collier's data was not used most of the time.
(1972:128, 146).

Maeda notes that the Fo pattern in simple NPs of the type Adj+N, Adj+ Adj+N, or Adj+N+N can often be described with hat patterns. More complex NPs such as those with PPs after the head NP can be realized with a phonetic group pattern on each unit (i.e., NP or PP), or with more than one unit within a phonetic group (202). However, it appears from his Fo plots that the approximation of Fo in a phonetic group by a trapezoidal "hat" shape (196) is only a coarse model, and such a model is too restricted to account for all the data.

Related to this rise+flat+fall Fo pattern in a syntactic phrase is Hultzén's notion that, in a sentence, "the first and last accent positions are comparatively conspicuous," providing "for two information points" (1959:110), and Bolinger's claim that "we give the major pitch prominence to the initial and terminal items" in an utterance. Bolinger notes that such an Fo pattern can exist "even in the absence of normal syntactic interrelationships," e.g., "in reciting QED, H2SO4, do-re-mi, consecutive numerals, and the like" (1965:158). He refers to this pattern as one "of the main functions of accent," viz., as a "mechanical" "sentence-binder" (1957b:311).

6.2.4.1) Simple Verb Phrases

The data in the following sections is from set G. Perhaps the most straightforward examples of P-units are VPs containing sequences of V+prep+
art+N, with the initial Fo rise on the accented verb and the final fall on the accented noun. Short utterances with such VPs usually have 1 or 2 P-units: if the subject has 2 or more ASs, it forms a separate P-unit, otherwise the entire utterance forms one P-unit (with the verb contributing to the medial Fo pattern) (Fig. 114). In Table 110, #1, the subjects had 2 or more ASs, and Fo reached the BOR at the end of the subject (106 Hz); the ensuing pattern on ". . . live on the (ice; land)" formed a P-unit, starting with a +25 rise accent and ending with a -38 fall accent. In contrast, the intermediate USs ("on the") averaged only -5 fall-off each, ending at 119 Hz (above the BOR). Such a gradual fall-off rate differed considerably from the -38 fall on the final AS of the P-unit (which, in addition to the sharp fall accent, had a +8 rise accent).

The P-unit also appeared in VPs with a particle following the verb, as in ". . . dig up berries" (#3). After a +14 rise accent on "dig," Fo in the particle "up" remained high, in preparation for the -22 fall accent on "berries."

In #2, the subjects had 2-4 ASs, followed by the VP "live in the Arctic." As above, the P-unit in this VP began with a rise accent (+17), averaged a slow -4 fall-off per medial US, and ended with a fall accent (-30). One difference was that the final word ("Arctic") had 2 syllables (with the first stressed); this led to the major portion of the final fall occurring between the vowels of the final word, rather than during the accented nucleus, as in a monosyllabic final word.
When the subject is short instead (e.g., only one AS), the utterance frequently has only one P-unit, e.g., in the sentences "The bears live (on the ice; with the gulls)" or "Bears live in the Arctic," (#4-5, respectively). Very similar except for the syllabic difference in the final noun (as discussed directly above), these 2 patterns differed from those in #1-2 in that the P-unit started with a large rise accent on the subject noun. Thus, instead of initiating the P-unit with a sharp rise, the verb here had the typical pattern of medial ASs in the P-unit, in which Fo dropped between the accented vowels of the subject and the verb (in anticipation of the rise accent on the verb), and the verb accent was smaller than when starting a P-unit. The average -10 descent on the ensuing USs was larger than the rate in #1-2 (likely due to the higher Fo level), but was still much less than the -33 fall accent on the final noun. Similarly, #6 shows the patterns for the same sentences as #4, except that these had 1 or 2 extra PPs following the first PP. The anticipation and 'carrier' (positional) Fo effects raised the Fo levels with only minor modifications to the P-unit pattern: the intermediate USs averaged -14 descents each, compared to a -49 final fall accent.

While VPs containing PPs provide good illustrations of the P-unit, simpler VPs also form P-units. A VP consisting merely of V+N ("eat lemmings" - #7) formed a P-unit after a long subject. When the P-unit contains only 2 words, it is hard to refer to the Fo curve as a 'plateau' or 'hat pattern,' since Fo does not remain high and flat over any span of time. Yet the characteristic sharp initial rise and sharp final fall still
occur, and a lack of a 'top' to the 'hat' is only due to the dearth of medial USs. As above, when the subject was short (e.g., "Bears" in #8-9 vs. "The bears in the Arctic" in #7), it initiated the P-unit and the verb became a medial AS with less Fo variation. One interesting difference, which may be related to the lack of separation in 3 successive ASs ("bears eat lemmings"), was that the first portion (about 40%) of the verb's vowel had slowly-falling Fo, after which Fo rose more rapidly in the last portion, to mark accent. Again however, consistent with other P-units, less total Fo variation was observed on medial ASs than on exterior ones (e.g., the net Fo change on "eat" was only +8 Hz). The 2 different Fo levels in #8-9 reflect location: in the former, the phrase ("bears eat lemmings") was in utterance-final position (and had a pattern very similar to #7, which was also utterance-final); whereas in the latter, the phrase occupied non-final position, with concomitant higher Fo and a CR at the end of the P-unit.

Another example of a 3-AS P-unit occurred in #10-11; the sentence involved 2 clauses, with P-units encompassing the VPs ending the first and second clause, respectively. Each one followed a long subject, thus enabling each VP to occupy a P-unit by itself. The +35 initial rise and -53 final fall of the unit in the first clause were larger than those in the second (which were +24 and -26, respectively) due to a positional effect; but in both cases, the Fo movement in the medial USs was small compared to that in the ASs. USs in this span averaged a (+2, -6) pattern, with a net fall-off of only -4 Hz/syllable. This contrasted with the (+8, +7, -13) pattern on the AS of the medial verb ("live," inhabit"), which marked accent
via the +15 Hz obtrusion, but had little effect on the broader pattern
since the net Fo change (rise+fall) on the AS was only +2 Hz. Thus the
Fo pattern on a medial AS in a non-initial P-unit appears to be a rise+fall,
each approximately the same relatively small size. This differs from the
sharp rise or fall of ASs at the exteriors of a P-unit, and differs also
from medial ASs in initial P-units, where there is a greater tendency
toward larger Fo falls since the Fo level there is higher.

6.2.4.2) Simple Prepositional Phrases

Often a PP does not modify the phrase it immediately follows, as in
"The bears live on the ice with the gulls in the winter" (#12), where the
latter 2 PPs modify the verb, not the preceding PP. In these cases, each
PP formed its own SC and did not join with a nearby phrase to form a P-unit
(Fig. 115). The Fo pattern for "with the gulls" here was marked by low
Fo in the BOR for the initial 2 USs, then a combined rise and fall accent
on the AS "gulls," and finally a small CR. #13 illustrates similar results
for PPs with bisyllabic accented words in utterance-final position.

When such a 'disjoint' (verb-modifying) PP was utterance-initial (e.g.,
"In the Arctic, the bears eat lemmings" - #14), the basic pattern was not
changed; only the Fo levels and amounts of variation were higher (cf. #14
with #13). (Utterance-initial Fo in the USs was above the BOR, which is
typical of Fo in function words with some information. The preposition "in"
started at a higher Fo value than articles (such as "the") did, most likely
because the preposition conveys more information (being selected from a
wider set of alternatives).

In forming P-units, PPs can 'attach' to nouns as well as verbs. "The bears in the Arctic" (#15) differed in Fo patterning from "live in the Arctic" (#2) only in Fo levels and amounts of Fo change: as a subject in utterance-initial position, the NP example had an overall Fo level about +45 Hz higher, with concomitantly larger rises and falls. In particular, Fo fell-off at a rate of -15 Hz here on the USs, compared to a -4 Hz rate in the VP example. However, as above, this fall-off rate was small compared to the fall accent on "Arctic" (-47 Hz).

6.2.4.3) Two-word Noun Phrases

Simple NPs consisting of 1 or more adjectives followed by a noun invariably form P-units (Fig. 116). Cases of such subject Adj+N NPs (both monosyllables) are shown in 111, #1-4. In #1, only a simple monosyllabic verb followed the subject NP, while in #2, a longer VP ensued. In both examples, Fo rose sharply on the adjective (which started the P-unit) and fell on the noun (which ended it). Besides the higher Fo in #2 (due to anticipation), some minor pattern differences appeared on the noun: #1 had a small (+2) rise to help note accent on the noun, whereas #2 had no such rise, but instead ended with a CR, which #1 did not have. The lack of accent rise on the noun in #2 can be related to the competition effect of a longer VP, and the lack of a CR in #1 can be attributed to the small amount of the utterance remaining after the noun (i.e., only one syllable).
When Adj+N NPs occurred in parallel subject positions in conjoined clauses, the first subject's Fo pattern was altered. #3-4 and #5 show the results for the NPs in the first and second clauses, respectively, of such utterances. The VPs here were long enough to warrant a small CR at the end of each subject NP, but only the NP in the second clause had a CR. Other than the lack of a CR in the first NP, #5 differed from #3-4 mainly in Fo level. However, the sharp fall indicative of the final AS in a P-unit was not present as such in #3-4. Instead, Fo rose during most (75%) of the vowel's duration before sharply falling in the latter portion. While this appears similar to the pattern in #1, it differs in that in that earlier case the rise occupied only the first 13% of the vowel (i.e., most of the vowel had Fo fall). This shift on the final noun of a P-unit from Fo fall to mostly Fo rise appears to be a device by which the speaker highlights the comparison of the subject NPs in parallel positions, and is discussed further below.

The question arises whether the Fo patterns in #1-5 can be called P-units, since the amount Fo fell during the final noun was not sufficient to reach the BOR. In #1-2, Fo fell -20 during the final noun and the next syllable had a +24 rise accent, but Fo only reached a low of 124 Hz. In short utterances such as these, where one AS ended a syntactic unit and the next started the next unit, Fo often did not reach the BOR until the end of the utterance. But since the basic pattern of the P-unit (rise at start, fall at end) occurred, the patterns in #1-2 can be considered P-units.
#3-4 present a different situation. In #3, the entire first clause ("The big bears hunt and kill, . . .") appeared to form only one P-unit, where "bears" and "hunt" constituted medial ASs, since Fo never fell below 145 Hz there until the final word, and Fo variation throughout the medial words was small (only +8 Hz accent obtrusions on "hunt" and "bears"). In #4, however, the subject NP constituted a P-unit because, while Fo only fell -14 at the very end of the noun, the next word ("are," an aux) had a -25 fall-off to 115 Hz. That this fall-off did not occur on the final noun is likely due to the parallel effect, which altered the noun's Fo. The utterances in #3-4 differed in the durational distribution of the final noun: while #4 had an Fo rise in 75% of the vowel before the late fall, #3 had only 22% rise (thus most of its vowel had Fo fall). This difference, in addition to the difference in number of P-units, can be related to the different parallel constructions of the utterances. The sentences of #3 were less 'parallel' than those of #4 in that the former had different co-ordinate constructions in subject and object positions of the 2 clauses.

#6 shows the subject Fo pattern for an utterance similar to that in #1, except that the final noun ("foxes") and the ensuing verb (scavenge) were each bisyllabic, which led to higher Fo values (through anticipation). In addition, the presence of an intervening US between the last AS of the subject and the first of the verb appeared to allow a sharper Fo fall-off in "foxes," as well as a small CR (marking the subject-verb boundary). In #6-8, the sharper final word fall-off in the subject led to a clearer marking of the end of the P-unit.
#7 illustrates a double-bisyllabic subject ("Arctic foxes"), which preceded a lengthy VP. The Fo behavior on "foxes" was similar to that of #6, with the exception of a larger CR and a lack of an accent rise, which, respectively, were likely due to the additional important words following and to a competition effect. In #8 however, "foxes" did not have as sharp a fall-off in Fo and it only had a very small CR. #8 differed from #7 only in that the VP was longer (containing 2-4 conjoined NPs vs. only 1 NP in #7). The Fo difference appears to be one of competition and/or FSF progression: with more ASs present in #7, each got less accent, and in addition, the longer final complement NP received more relative accent via the de-accenting of "foxes" in the subject. Even though Fo only fell to 142 at the end of "foxes," Fo still attained a low level before the second P-unit started, since Fo continued to fall -26 during the ensuing aux.

In starting a P-unit, the initial adjective in #7-8 ("Arctic") exhibited an 'overshoot' Fo effect, in that Fo only attained its peak value during the second, unaccented syllable, rather than on the first, accented syllable, where most of the rise occurred. #9 illustrates a multi-syllabic final complement NP ("persistent scavengers"), where again the P-unit pattern occurred. After the sharp +49 rise on the AS of the adjective, the descent to the ensuing US was only -1, compared to the much sharper fall-off on the final noun. Incidentally, Fo jumped +11 on "per-" (the initial US of "persistent"), which might have indicated accent if Fo were not in the BOR and followed by the much larger rise accent of "-sis-".
6.2.4.4) Three-word Noun Phrases

112, #1-3 show F0 patterns for subject NPs with 3 monosyllabic accented words forming a P-unit. Three different patterns emerged among these NPs, 2 of them for the same sentence spoken at different times in the same corpus. All 4 utterances had similar F0 shapes on the initial word, viz., the typical sharp rise initiating a P-unit. On the second word, 2 utterances (#1-2) had a rise+fall pattern similar to that in 111:4 (an (-10, +11, -16) pattern, with 67% of the vowel duration spent on the rise); whereas the other 2 utterances had a fall+rise pattern similar to that in 110:8-9 (an (-11, -11, +6) pattern, with 50% of the vowel spent on the rise). The choice between these two ways of exhibiting accent on a word medial to a P-unit appeared to be a free variant.

For 3 of the 4 examples, the final noun exhibited the standard sharp fall + CR (-32 fall, +7 CR), but the fourth (#1) had a rise+fall pattern, quite similar to that of the preceding word (again with most of the vowel (88%) spent on the rise). This option was similar to that in 111:4, and appears to be a variant designed toward less F0 variation than in #2-3, since F0 did not fall as low at the end of the subject, and thus did not have to rise as far on the ensuing AS. Of course, this option leads to a less clear boundary-cue between the subject and verb.

Sentences with final complement NPs consisting of 1, 2, 3, or 4 conjoined 3-word NPs have their ten individual NP patterns of F0 shown in #4-12; the patterns were averaged across the 4 utterances by sentence
position and syllable structure. The initial adjective in each NP started a P-unit with a sharp Fo rise peaking on the AS (if monosyllabic – #4) or on the ensuing US (if bisyllabic – #5). The medial adjective showed little Fo variation other than a gradual (-5 Hz/syllable) fall-off if bisyllabic (#8); if monosyllabic, the medial word had a small accent rise late in the vowel (which was smaller, due to a competition effect, in non-utterance-final NPs (#7) than in final ones (#6)). The final word in the NP had a +13 CR if non-utterance-final (#10, 12), exhibited very small accent rises if bisyllabic (#11-12), and in all cases had sharp Fo fall-offs (averaging -25 Hz) to Fo levels in or below the BOR (104 if non-final; 93 if final). As above, the net fall-off rate on the medial words was small compared to that on the final word (-16 vs. -25 Hz), especially if a comparison is made of the within-vowel net Fo changes for the monosyllables (-6 vs. -27 Hz) and of the descents for the bisyllables (0 vs. -23 Hz).

6.2.4.5) Four-and Five-word Noun Phrases

Table 113 and Fig. 117 show the Fo patterns for 4- and 5-word subject NPs, which each formed P-units; #1 & 3 illustrate different versions of "small yellowish polar bears," while #2 & 4 show those for "large pure white polar bears." In single-clause utterances (#1-2), each medial accented word (i.e., "yellowish," "pure," "white") had an Fo pattern of drop+rise+fall on its AS, which averaged (-14, +8, -8). The USs in "yellowish" each averaged a -11 fall-off, with no accent rise. The final accented word in the P-unit ("polar") had a sharp fall-off (a -17 descent, and another -30 fall during the US itself); "polar bears" appeared to
function as a **compound**, with "bears" getting no accent and behaving as the final US in the unit (where a CR occurred). The larger accent and higher Fo on "pure" than on "yellowish" may be due to the deviation of the syntactic structure from **right-branching**, which all the other examples have been. Since "pure white" functions as an adjectival phrase, its first element may systematically receive more accent, in a type of 'compound' relationship (whereby the first element of a unit gets the greater accent).

When these same subject NPs occurred in a 2-clause utterance, the one in the first clause (#4) got higher Fo levels than the one in the second clause (#3), due to the carrier effect. In addition, a more fundamental difference, related to the **repetition** and **parallel** Fo effects, occurred in the accent pattern. With these 2 NPs occurring in parallel subject positions, some of the lexical differences ("pure white" vs. "yellowish") were contrasted and emphasized with larger accents (an average of +11 Hz more), while the identical elements ("polar bears") received less accent. Actually, the first occurrence of "polar" (as a 'new' word) got the same amount of accent as in the single-clause case, but the second occurrence (as a repeated word) was much reduced in accent. Another difference related to this change was that the Fo fall ending the P-unit in the second clause occurred on "**yellowish**" rather than "**polar**," since the former had become the final AS in the subject: the Fo fall-off rate in the USs of "yellowish" in #3 was -30 Hz/syllable, compared to -11 Hz/syllable in #2.
6.2.4.6) Two words conjoined with "and"

Most syntactic phrases consisting of 2 words joined by a conjunction formed P-units. For example, in the sentence "The bears are large and white, and the foxes are white and quick, and the gulls are small and shrill," each of the complement adjectival phrases formed a P-unit (114, #1-3). The first adjective of the P-unit had a +30 rise accent (and 142 peak), which marked the start of the unit, while the -59 fall accent on the final adjective of each unit marked its end. (The very large Fo fall-off, as well as the large rise accent (+23), on the final adjective can be related to the parallel structure of the sentence, which enhanced the accents of the parallel elements). The effect a P-unit has on the Fo of an US is well illustrated here by comparing patterns for "are" and "and": the unaccented copula preceded the P-unit in each case and had an average pattern of (-27, -10) from a 149 Hz level, whereas the conjunction was medial in the P-unit and had a pattern of (+6, -6) from a 133 Hz level. Even accounting for the lower Fo level, there was much more net fall-off on the 'normal' US (-37 Hz) than on the P-unit US (0 Hz).

#4-7 show Fo examples of other simple clause-final co-ordinated phrases. The P-unit patterns can be seen in "The big bears hunt and kill . . ." and in "The (big) bears are (the) hunters and killers . . ." (with sentence-final versions in #4 & 6, and non-final ones in #5 & 7 with terminal CRs, respectively). The best example of the 4 is #6, where the medial USs in the P-unit averaged a net fall-off of -10, compared to -35 in the US preceding the unit. The distinction was not always that dramatic,
however; in #4 & 7, the medial fall-off rates averaged -19 Hz. Even this larger rate was small, though, compared to the fall accent on the final word.

In subject position, simple conjoined nouns exhibited typical P-unit patterns ("Bears and gulls . . ." in #8; "The gulls and foxes . . ." in #9), although the higher Fo levels of initial utterance position apparently led to a larger -15 Hz/syllable rate for the unaccented conjunction. When 3 or more nouns are conjoined to form a subject NP, commas may replace conjunctions as separators of the co-ordinated elements. Since conjunctions are function words (normally unaccented), their deletion from an utterance had mainly local effects on the Fo contour. 115, #1-4 show the patterns for such subject NPs with 3 nouns (#1-2) and 4 nouns (#3-4). In #1 & 3, each pair of nouns was separated by "and," while in #2 & 4, commas were used, except in the last noun pair. Besides the higher Fo in the first of each pair of utterances (from an anticipation effect, due to the presence of more "and"'s, apparently), the presence of "and" between 2 nouns had little Fo effect: in the 3 cases of deleted "and"'s in #2 & 4, the -22 fall-off that occurred on the conjunctions on #1 & 3 was replaced instead by a sharper Fo drop prior to the accent rise of the ensuing noun.

6.2.4.7) Larger Conjoined Combinations

In #5-10, the subject NPs consisted of 2-4 conjoined nouns; 4 different nouns were used, 2 monosyllabic and 2 bisyllabic. The averaged Fo patterns for these nouns in initial, medial, and final positions in the NP
are shown in #5, 7, & 9 for the monosyllabic nouns, and in #6, 8 & 10 for the bisyllabics. The average pattern for all the cases of "and" conjoining these nouns was (-3, -9) from a 155 level, illustrating the slow fall-off rate of medial USs in P-units; however, 4 of the 46 examples had an average -33 fall-off (which indicates that not all phrases consisting of conjoined nouns form single P-units). The Fo patterns for the nouns in initial and medial positions were very similar, with the exception of lower Fo levels and smaller variations in the medial position. Within the ASs of these nouns, the durational distribution of Fo rise to fall was 84 to 16% for the monosyllabics (#5 & 7) and 85 to 15% for the bisyllabics (#6 & 8). In the bisyllabics, Fo continued to rise in the ensuing US before reaching the peak Fo in the noun. This 'overshoot' behavior occurred frequently in multi-syllabic accented words where the AS was not word-final and where the word was not the final accented word of a syntactic unit. These patterns of accented words with virtually all Fo rise before a small fall-off late in the word can be considered indicative of non-final elements in a co-ordinated phrase. In contrast, the final nouns in these subject NPs (#9-10) were marked by rapid Fo falls with only small rise accents. For example, "bears" and "gulls" in final co-ordinated position had a (-9, +2, -28, +9) pattern, with 61% of the vowel spent on the -28 fall, only 8% on the preceding Fo rise, and the remaining 31% on the CR.

As was illustrated in Table 112, not all syntactic phrases consisting of conjoined units formed single P-units. There, 3-word NPs each formed a separate P-unit, even though the NPs were themselves conjoined to form a
larger NP. On the other hand, the results in Tables 114 & 115 indicate that phrases consisting of conjoined single words usually do form single P-units. 116, #1-2 show that 2-word conjoined NPs appear to follow the pattern of Table 112, with each NP forming its own P-unit. In the subject NP ("The white gulls and quick foxes . . ." - #1) as well as in the complement NP (". . . clever hunters and dangerous killers" - #2), each of the initial words in the 4 individual NPs had the sharp-rise+relatively-level Fo pattern; in "clever" the accent rise overshot into the US "-er", and in "dangerous," the fall-off rate in the 2 USs was only -6 Hz/syllable. If the 4-accented-word NPs were to function as a P-unit, Fo would remain high through the second word and the conjunction; but it did not, since Fo fell -20 to 108 during "and." In addition, Fo underwent a rapid fall-off in "hunters," complete with a terminal CR, clearly marking "clever hunters" as a separate P-unit. "Gulls," on the other hand, followed an Fo pattern indicative of a non-final word; however, Fo did not remain high during the ensuing "and," and so "white gulls" became a P-unit (but without the clear-cut boundary which would be present if Fo fell sharply in "gulls").

Semantic factors sometimes affect how an utterance is prosodically structured (Fig. 118). The speaker's choice of whether to use a P-unit on a particular syntactic phrase depends not only on a close surface structure relationship among the words in the phrase, but also on whether the elements to be grouped form a 'cohesive' unit in some semantic sense. Thus phrases such as "hunters and killers" or "bears and gulls" tended to form P-units. However, phrases like "lemmings and other animals" and
"lemmings and many other small animals" (117, #1-2) did not form single P-units. Instead, these object NPs were split so that "lemmings" joined with the first portion of the utterance to form one P-unit (viz., "The bears eat lemmings . . ."), leaving the rest of the object to form a separate SC or P-unit. While one would not expect a prosodic break between the verb and object in these short sentences on syntactic grounds, the full break which occurred in the middle of the object should be even less expected. There apparently is some semantic property inherent to words like "other" which leads to a 'disjoint' relationship in a coordinated NP which ordinarily would be 'cohesive.' In "lemmings and (many) other (small) animals," "lemmings" is the important information, and the second phrase represents a form of reduced (if not 'old') information. Thus, while the second phrase received accent on the first word ("other" in #1 and "many" in #2), the remaining words in the utterance received little accent: "animals" in particular, being a superset of the previously-occurring "lemmings" was fully de-accented with its Fo remaining inside the BOR. In "many other small animals," the middle words had the slow fall-off rate typical of P-units, with an average pattern of (-1, -8) on each syllable of ". . . other small . . ."; the relative predictability (given the preceding word "lemmings") apparently led to neither word being marked with an accent rise.

6.2.4.8) Unaccented Syllables in a Phonological Unit

Besides the initial rise and final fall, the third major characteristic of a P-unit is the slow fall-off rate of medial USs. A comparison of Tables
118-119 highlights this difference for function words outside of and inside of P-units, respectively. P-units virtually never cross clause boundaries; thus any function words adjacent to such a boundary lie outside any P-unit. Three such Fo patterns for "and (the)" after a clause boundary are shown in 118, #1-3: in each case, Fo remained entirely within the BOR, independent of the prior Fo values; in #3, where the prior Fo value was 140, Fo simply dropped down to the BOR at the clause break.

The rest of Table 118 concerns function words not in P-units but within clauses, rather than at their boundaries. In each case, Fo appeared to 'aim' for an Fo level of about 105 Hz, with larger Fo movements occurring in those cases where Fo started further from 105. After a one-word subject (#5), Fo was relatively high (151) and had a -36 fall-off on the ensuing US "are." After 2 words in the clause (#4, 6, 8, & 10), the US had an average -23 fall-off from a lower prior Fo value of 131. After 3-5 words (#7, 9, & 11), the fall-off averaged -12 from a 117 level. Finally, after 5-8 words in a clause, Fo had fallen into the BOR at the P-unit boundaries, and from a 95 level, Fo rose +9 in the ensuing US (#12); such a rise did not mark accent because Fo remained within the BOR. While the range of Fo values prior to each function word here averaged 95-151 Hz, the Fo range at the end of the word was only 102-115 Hz. This Fo behavior of rapid 'convergence' toward the upper part of the BOR was typical of USs between P-units.

In contrast, function words within P-units exhibited less rapid Fo
fall-off, with Fo usually remaining above the BOR. After one word in
the clause (119, #1, 2, & 4), Fo averaged a high 164 Hz, but the ensuing
US had only a -12 fall-off. After 2 words in the clause (#5-6), the next
2 USs had average fall-off rates of -11 and -10 per US, respectively, from
an Fo level of 149. After a longer span of words, the fall-off rate for
USs within a P-unit was even less: -4 Hz/word from a 130 level (#7). While
the rate was sometimes more rapid from higher Fo levels, the rate was small
in comparison with that in USs outside of P-units, at similar Fo levels.

6.2.4.9) Multi-syllabic Accented Words

Table 120 shows Fo patterns for multi-syllabic words in various
utterance positions. #1-12 contains the results for 4 different words, each
in 1 of 3 different locations: utterance-final (#1, 4, 7, & 10), phrase-
final (#2, 5, 8, & 11), and within-phrase (#3, 6, 9, & 12). In each of
these triples, the same pattern occurred: from an Fo above the BOR at the
end of the AS in each word, Fo observed one of 3 movements: if utterance-
final, Fo fell rapidly to a level below the BOR; if utterance-medial but
phrase-final, Fo again fell rapidly but not below the BOR, instead a CR
ensued; if within-phrase, Fo fell at a much slower rate, remaining well
above the BOR. Similar observations can be made for the rest of Table 120.
Averaging across the 92 cases of utterance-final multisyllabic words, the
pattern on the accented and ensuing unaccented syllables was (+4, +u, -10)
126 (-19, -11); for the 56 phrase-final ones, (-8, +6, -12) 148 (-21, -6,
+9); for the 42 within-phrase ones, (+3, +16, -3) 149 (+6, +2, -11). Thus,
within a word, the US observed one of 3 general patterns after an AS:
starting at a level of 116, it fell-off -30 Hz, to below the BOR; from a 136 level, it fell-off -37 and then rose +9; from a 146 level, it had a net fall-off of only -3. Depending on which course Fo follows on such an US, it helps signal the corresponding syntactic information of the word being: utterance-final, phrase-final, or within-phrase, respectively.

The phrase-and utterance-final patterns were very similar, except for the higher Fo levels and the CR in the former. On the other hand, while the Fo levels of the phrase-final and within-phrase patterns were similar, their rise/fall movements differed considerably, with the US of the latter much higher than in the former. In one phrase-final case (#13-14), 2 patterns emerged: while both ended with a small CR, one showed the typical sharp Fo drop between syllables, whereas the other had a smaller drop-off. This latter pattern, which reached a low Fo of only 126 Hz (cf. the average of 109), appears to be a 'weak' version of the phrase-final marker, and can be related to the larger number of words remaining in the clause in the #14 case.

6.2.4.10) Monosyllabic accented words

Whereas many polysyllabic accented words had rising Fo accent movements occurring on more than one syllable, monosyllabic accented words contained most of the relevant accent gestures within their single syllables, often necessitating more than a single simple rise or fall on the syllable. Table 121 shows the Fo patterns of such words in various utterance positions. Throughout the results, the unvoiced words exhibited a pattern of higher Fo
peaks and larger prior jumps than did the voiced words (cf. #2, 6, 9, & 18 with #1, 5, 8, & 17, respectively). This Fo voicing effect appeared relevant only when the AS received a prior jump; in the phrase-medial cases (#10-11), where the accent was marked by a rise rather than a prior jump, no Fo difference due to voicing was found. An unvoiced initial consonant in an AS correlated well with a prior Fo jump larger than the ensuing vowel Fo rise (with about a 2:1 Fo ratio for the unvoiced cases, vs. a 1:2 or less ratio for the voiced ones). However, when the words "big" and "dig" initiated clauses (#3, 7), the prior jumps were larger than the rises. Thus, while most of the voiced words ("white," "bears," "live," "eat," "gulls," "large") and all the unvoiced words ("quick," "small," "shriil," "hunt," "short," "said") here followed the distribution given above, there were exceptions. Both "big" and "dig" are sufficiently phonetically similar and functionally diverse to lead to speculation that other phonetic factors besides simple voicing are relevant. It may be that the normal voiced word pattern is altered when the syllabic nucleus is short, as occurs when a lax vowel lies between 2 obstruents (as in "big" and "dig").

Among syntactic factors, whether a word was at the start, middle, or end of a phrase, clause, or sentence had apparent Fo effects. Among accented words initiating a unit, besides the +13 higher peaks in the unvoiced cases, words starting an utterance had peaks averaging +19 more than those starting non-initial clauses, which in turn were +16 higher than those starting clause-internal phrases (cf. #1-4 with #5-7 with #8-9).
In phrase-medial accented words (i.e., those neither starting nor ending a phrase), the usual pattern was one of prior drop + accent rise + small fall (#10). However, when 3 content words occurred in succession to form a phrase with no intervening function words or USs (e.g., "Bears eat lemmings," "short sharp muzzles"), the middle word had a different pattern: prior drop + small fall + accent rise (#11). This occurrence of a late accent rise (which might be confused with a CR, except that it occurred at a high Fo level and without any large prior fall-off) appeared only in this restricted environment of rapid succession of PA syllables.

In most of the accented words ending a syntactic unit, the characterizing Fo pattern was one of a (usually small) rise accent followed by a large fall-off (#12-19). In words ending clauses (#14-15) and ending non-clause-final phrases (#12), a CR usually marked the final Fo after a large fall, with larger CRs occurring in the clause-final cases. However, in short clauses (with 3 or 4 content words), the Fo effect of a NP+VP boundary was marginal (#13), with the pattern similar to a phrase-medial word but with less rise accent and more fall-off. A main differentiating characteristic of the clause- and sentence-final accented words was whether the word was part of a P-unit phrase (#14, 17-18) or not (#15 & 19). While they all had large Fo fall-offs, the prior rise accent was much larger when the final word formed an SC by itself than when it shared a P-unit with preceding words.
6.2.4.11) Different types of conjunction

The use of different conjunctions can affect the Fo pattern of a co-ordinated phrase. For example, in "John had a fearless and brave son" (122, #1), "fearless" had a small -1 descent, but in "John had a fearful yet brave son" (#2) and in "John respected but feared the people" (#3), "fearful" and "respected" had large -55 descents. Further, the first 3 peaks in #2-3 were +25 higher than in #1. Thus, the use of a 'disjunctive' conjunction ("but" or "yet") rather than "and" apparently led to increased accents on the conjoined words.

Adding "not" to "John and _____ Mary came to the party" (123, #1-2) broke up the P-unit on "John and Mary" in #1: the descent on "John" increased by 42, and "not Mary" formed a P-unit instead (ending with a 16 greater fall accent and a CR +8 bigger than in #1). Replacing "and" with "but" (#3) retained "not Mary" as a separate P-unit, but decreased the Fo breaks at its boundaries (12 less descent on "John"; 13 less descent on "Mary"; no CRs). Thus, the use of "not" in a simple co-ordinated phrase inserted an Fo break, but the use of "and not" led to larger Fo breaks than "but not."

6.2.4.12) Expressions

'Expressions' such as "The less (that is) mentioned, the better for all of us" (124, #1-2) and "The more money they have, the less they spend wisely" (#3) led to single P-units occupying the entire first clauses. In "that is" (#2) and "money they" (#3), Fo averaged a fall-off rate of
only -9 Hz/syllable from a high 195 level, followed by a large -49
descent at the end of the clause. In the second clause, however, #1 and
#3 had 2 P-units, while #2 had only one. Thus expressions of this type
led to single units in the first clause (with concomitant flat Fo on a
medial content word such as "money"), but only the option for a single
P-unit in the second clause.

6.2.5) Indirect Objects

The Fo patterns of sentences with 2 objects, one direct and one in-
direct, are shown in Tables 125-126. In Table 125, "Mary asked a question
of her partner" (#1) and "Mary asked her partner a question" differed in
the positions of the 2 objects, and had peak patterns of 146-122-132-114
and 141-121-121-113, respectively. The first, second, and last ASs had
similar accents in #1-2, but "question" in #1 had more accent (+5 more,
+11 higher peak) than "partner" in #2 in a similar position. Thus the
indirect object had less accent than the direct object in similar sen-
tences with comparative word structures.

Similarly in 126, #1-2 ("A nice neighbor has given (a few pots to my
old friend; my old friend a few pots")", with peak patterns of 147-135-
124-131-124-105-111 and 154-137-129-120-125-113-114, respectively, the
direct object in #1 ("a few pots") had more accent than the indirect object
in #2 ("my old friend") (+13 more, +11 higher peak). In addition, the
indirect object here was relatively de-amphasized by increased accent on the
preceding verb in #2 (+5 more, +5 higher peak).
Adding further phrases to the sentence in #2 had a small Fo effect on the indirect object, as shown in #3-5. In #3, "with the beard" was inserted after "friend"; in #4-5, "from his kitchen (in the blue house)" was further added after "pots." These additions had little consistent effect on the Fo pattern preceding the indirect object, but with "my old friend with the beard" as the new indirect object, "old" gained accent (+12 more, +4 higher peak) and "friend" lost accent (-5 less rise accent, -5 lower peak, 10 less descent). This can be related to the further specification of the NP by "with the beard": "friend" provided less important information and "old" shouldered a heavier information load.

Adding 1 or 2 further PPs after "a few pots" (#4-5) had the effect of increasing its accent: "few" had +17 more accent and +18 higher peak than in #2-3. Similarly, adding "in the blue house" (#5) raised the accent on "kitchen" (+10 more, +10 higher peak, than in #4). These 2 effects are related to the Fo carrier and anticipation: an AS tends to have more accent if more ASs follow than when it ends the utterance. However, the Fo pattern prior to "few pots" showed little variation with the addition of the last 2 PPs in #4-5. Thus the anticipation effect here was local. One difference that did occur earlier in the utterance, however, was the increased use of a CR at the subject-verb boundary: in #2, there was no CR; in #3, it was +4; in #4-5, it was +8. Thus the longer utterances in #3-5 led to greater Fo breaks.

In Table 127, pronominalization and changing word order was tried on a
simple sentence with 2 objects ("Cal gave a rug to Sue" - #1). #4 had "Cal gave Sue a rug," and #2-3 had the respective versions with "rug" and "Sue" pronominalized. With 2 nouns, the first object ended with a sharp -44 descent and a +11 CR. With one pronominalized, there were no CRs. It may be that the indirect object form is more 'basic,' since lower Fo peaks occurred in #3-4, than in the utterances with a PP. Unlike the results above, "Sue" here got more accent than "rug"; thus an indirect object does not always have less accent than a direct object. When the indirect object names a specific person and the direct object is indefinite (as here), it appears that the indirect object gets more accent.

6.2.6) Summary

The Fo patterns of many utterances can be described as containing sub-patterns called 'P-units,' in which the first AS had a sharp rise and the final AS had a sharp fall. Fo within a P-unit fell at a relatively slow rate, with Fo remaining above the BOR. Fo in USs outside of P-units 'aimed' toward a level in the BOR, while Fo in USs inside a P-unit stayed high. Fo in ASs other than the final one of a P-unit often 'overshot' into the ensuing US (most frequently on the initial AS when the following US was in the same word). Medial ASs in P-units had reduced accent patterns, and most often got small rise+fall shapes. When a medial AS was surrounded by other ASs, the speaker appeared to have a free option to give a fall+rise shape to that AS, where durationally the rise occupied most of the AS. A further option appeared on the final AS of a P-unit where it was the first of a set of 'parallel' items: rather than have a
sharp fall during the final AS, Fo rose during most of it, and most of the
descent was in the form of a drop between nuclei. The final AS in a P-unit
often had a rise accent in addition to its larger fall accent; non-final
P-units ended with Fo in or just above the BOR and often had CRs there.

P-units co-occurred with syntactic phrases in utterances. Exactly
which phrases got P-units was not deterministic, but there were strong
tendencies. Except in unusual cases, phrases with only one AS did not
form a P-unit; subjects of 2 or more ASs did, as did VPs consisting of
the verb with an ensuing PP or object. P-units were generally restricted
to 3 or 4 ASs; so longer NPs and VPs were broken into more than one P-
unit at major syntactic boundaries (e.g., at commas, conjunctions, or be-
tween PPs). PPs not modifying the verb did not form a P-unit with the verb.
In short clauses (1-3 ASs), the NP and VP often combined into a single
P-unit.

P-units, Fo breaks, and CRs were used in resolving syntactic ambiguities
in which the location of a syntactic boundary cued different meanings.
Essentially, sharp fall+rise patterns occurred at crucial syntactic boun-
daries in these utterances. These Fo breaks were especially useful in dis-
tinguishing several scope of 'modification' or 'application' contexts
(e.g., with quantifying and sentential adverbs, in multiple conjoined
phrases, and in sequences of PPs). Noun-verb ambiguities were resolved
with Fo breaks at the subject-verb boundary. Ambiguous word boundaries
could be cued with sharp Fo falls.
Both vocatives and appositives were preceded by big prior descents. Vocatives were not preceded by a CR, but appositives could have one (except where the appositive might then be mistaken as being in a 'list'). Vocatives had low Fo with Fo rising out of the BOR on its last syllable (similar to a CR, but occurring even in utterance-final position). Indirect objects tended to have less accent than direct objects in similar positions. Disjunctive conjunctions led to bigger accents on their conjoined words.

6.3) Continuation Rises (CRs)

One of the Fo cues that the speaker uses in segmenting an utterance is the CR. Major syntactic phrases (such as adverbial clauses, or conjoined or non-restrictive embedded clauses) usually have their terminations marked by a rapid Fo fall on the last AS in the phrase, with Fo on any ensuing USs before the syntactic break remaining in the BOR. If the phrase is the final one in the utterance, Fo continues to fall below the BOR to the lowest Fo value in the utterance on the very last syllable. This Fo fall to a very low level appears to signal 'finality' (i.e., the end of the main portion of the utterance), after which such items as 'afterthoughts' may ensue, or an entirely new utterance may start.

If the terminating phrase is non-final in the utterance, Fo does not fall below the BOR, and often rises at the end of the last syllable in a type of 'continuation rise,' which the listener apparently treats as a signal to continue paying close attention to what follows. This CR pattern of Fo executing a reversal in direction after a fall (within the same syl-
lable or word) appears to be an Fo gesture that the speaker uses to let
the listener know that 'more important information is yet to come' in the
utterance, and contrasts with the terminal Fo fall at the end of an
utterance.

The size of the CR appears dependent upon the 'strength' of the
boundary (major syntactic breaks have larger CRs), upon the lengths of the
phrases involved (longer phrases have larger CRs), and upon the amount of
new and important information following after the break (the more important
information ensuing, the larger the CR).

6.3.1) Inter-clause boundaries

The average Fo pattern of the 113 examples of CRs in set G constituted
a +10 Hz CR from an Fo value of 104 Hz, after a -37 Hz fall-off from the Fo
peak in the immediately prior AS. The largest CRs in set G were found at
the ends of non-final clauses in multi-clause utterances. When the clauses
did not form a strictly parallel relationship (e.g., in "The big bears hunt
and kill, and the white gulls and quick foxes scavenge," the subjects and
verb groups were of different sizes and structure), the average CR was +15
(128, #1). When the clauses did align in parallel fashion (e.g., in "The
large bears are white, and the small bears are yellowish"), 4 examples had
CRs averaging +29 at the end of the first of 2 clauses (#2); the 2 ex-
examples of Fo behavior at the end of the first of 3 clauses had the largest
CRs, averaging +38 (#3); the remaining 4 of the 10 examples, however, did
not exhibit CRs, with Fo instead falling below the BOR (#4); it appears
that, in these last 4 cases, the speaker 'ended' the utterance prematurely, and then resumed it with the final clause as a separate entity.

A CR can usually be expected at the ends of non-final clauses (12 of 16 cases here). In the 14 multi-clause utterances, only 2 non-final clauses had a CR \textit{internal} to the clause, whereas 11 final clauses had an internal CR. The 6 clauses with 5 or more content words (including the 2 in non-final clauses mentioned directly above) had an internal CR; but of the clauses with 3 or 4 content words, all 14 non-final clauses lacked an internal CR, while 7 of 8 final clauses had such a CR. Thus, in multi-clause utterances, clause-internal CRs can be expected: in non-final clauses containing more than 4 content words, and in final clauses with more than 2 content words. This reluctance to place a CR in a short initial clause is likely related to an objective on the speaker's part not to signal a major break (via a CR) in the utterance \textit{before} the final clause boundary.

6.3.2) Intra-clause boundaries

While the largest CRs occurred at clause boundaries, where commas marked the break in the orthographic form of the sentence, smaller CRs occurred at \textit{comma locations other} than at clause boundaries. When 3 or more multiple-word phrases were conjoined and also when a sentence started with a PP, the comma locations were marked with +12 CRs (#5). Commas conjoining \textit{single} words, as in a co-ordinated NP (e.g., "Bears, foxes, and gulls . . ."), were not marked in Fo by fall+rise (FR) CRs. On the other hand, of 22 cases where commas separated \textit{3-word} phrases, 21 had CRs. CRs
can likely be expected at comma locations separating phrases with 2 or more content words.

Among syntactic boundaries not marked with commas, the subject-verb group boundary often received a CR when the subject contained 2 or more ASs. In one utterance (#6), the long subject in the first of 2 clauses had a +14 terminal CR; in the other utterances with subjects of 3 or more ASs (#7), the CR averaged +8. The larger CR in the former case was likely due to the larger amount of utterance to follow the CR, compared to only 2 ASs remaining after the CR in #7. For subjects with 2 ASs in single-clause utterances, the average CR size was +7, independent of the size of the rest of the utterance (which ranged from 1 to 9 ASs).

In utterance-final phrases of 3 or more content words consisting of 2 NPs conjoined by "and," the initial NP was marked with a +13 CR, while the preceding subjects (with 1 or 2 ASs) had no CR (#9). Thus, while the NP-VP boundary is ordinarily a 'stronger' boundary than that between conjoined NPs, if the size of the full object NP exceeds that of the subject NP, the CR break may easily shift to the lesser boundary. As discussed above, when PPs modify the verb but do not immediately follow it, they do not form P-units with the preceding portions of the utterance, and instead become 'disjoint' phrases in Po patterns. In 6 of the 10 cases where this occurred, CRs (averaging +7) marked the boundaries.

Within clauses, the occurrence of a CR appeared to depend directly on
the number of content words in the clause. No CRs occurred in clauses with only 2 content words, whereas one CR occurred almost invariably in clauses with 5-8 content words, and more than one CR occurred in clauses with 9 or more content words (Table 129). In clauses with 3 content words, 26% had a CR; in those with 4 content words, 80% had a CR; and in those with more content words, 93% had at least one CR. In the 3-word cases, 5 of the 10 utterances with CRs were in the final clauses of multi-clause sentences, and the other 5 were in 1-clause sentences where a 2-content-word subject ended in an US (which had the CR) and at least 2 syllables ensued. In the 4-content-word cases, 4 of the 8 that failed to have a CR were those in initial clauses (discussed above).

In clauses which had internal CRs, comma locations delimiting more than one content word each were the primary choices for the CR locations. In clauses with CRs but without internal commas, the NP-VP boundary was chosen in 86% of the cases, the boundary between 2 conjoined NPs in 9%, and the boundary before a disjoint PP in 5%. In the 12 cases where a CR occurred at a boundary other than the NP-VP one, 10 utterances had subjects with only one content word (and the other 2 had 2-content-word subjects). In only one utterance did a CR occur after a phrase with only one content word (and that occurred in a final, parallel clause). Thus, when the subject NP had only one content word, but the clause was long enough for a CR, it usually occurred at the next logical break; e.g., at a conjunction or before a disjoint PP. Similarly, when the subject had only 2 content words and the VP contained 4 or more, if only one CR was to be placed, it
occurred in the VP. Hence there is a **trade-off** between the tendency for a CR to occur at the 'strongest' or 'highest' syntactic boundary (in the surface structure tree) and for a CR to divide the clause up into smaller units of relatively even size. Within the constraint that the CR occur not too early in the clause, it is located at the strongest boundary.

In the long clauses (more than 8 content words) of this set, commas marked intra-clause boundaries and provided the CR locations. In these cases, the occurrence of a non-comma CR (e.g., at the NP-VP boundary) appears optional; of the 4 cases here, only 2 had a CR at the end of the subject, and they were small (+4 Hz) compared to the comma CRs (+16 Hz).

6.3.3) Tunes I and II

In describing terminal intonation contours, Armstrong & Ward (1926) postulated two distinct ones: Tunes I and II. Tune I is identical to the Tune A contour described in 6.1.1. Tune II i... like Tune I, "until the last stressed syllable .... This is on a low note, and any syllables that follow, rise from this point," but "the rise is very gradual," and "if the last stressed syllable is final, the rise .... occurs within the stressed syllable itself." Tune II is used for "not so definite" statements; "something .... is implied but not stated, or the way is left open for further comment" (20). Tune II is **not** the typical yes/no question rise, but rather a rise+fall+rise (RFR) variant of Tune A. The Fo rise in yes/no questions starts from a higher level and goes higher than this Tune II rise (Lee, 1956:361).
With regard to the use of Tune II, Hirst & Ginesv claim that "a sentence [ending on an Fo] fall-rise is the result of the deletion of the right-hand constituent" of an underlying two-clause sentence, e.g., the sentence "She's nice," with a FR on "nice," would actually come from the sentence "She's nice, but she's not + Adjective," in which the second clause was deleted (1974:53). Thus, Tune II can be considered a type of CR in which what was to follow was instead left unsaid or implied.

Thus, the Fo patterns of finality vs. continuation are quite similar to Tune I and II, respectively. The Tune II FR pattern is a possible terminal Fo contour, the use of which would signal "inconclusive intonation" or "hedging," in contrast to the "conclusive intonation" of Tune I (Bolinger, 1957b:313). However, the CR is used as a non-terminal, to hold the listener's attention; it has no extra 'attitudinal' meaning, but simple indicates the incompleteness of the utterance. When reading text, the use of a CR is often related to commas, dashes, and parentheses, while Tune I falls tend to occur with periods and semi-colons (310).

Many authors have noted this "continuative" use of Fo (e.g., Crystal, 1969b:273; "the thought is incomplete": Mattingly, 1966:2; "unfinished": Isačenko & Schädlich, 1970:38; "comma pause": Stockwell, 1971:40; "tentative juncture": Lieberman, 1965:52; "pseudo-pause": Umeda, 1975:10; "linking feature": 't Hart, 1971:21). Kurath refers to the CR as a "sustain" Fo pattern, as distinguished from the statement "final fall" and the yes/no question "final rise"; this "sustain . . . marks the end of a
non-final constituent clause or phrase of a sentence" (1964:128). Mattingly
notes that CRs are used to "indicate the speaker has more to say . . . , or to
set off vocatives, quotations and parenthetical and non-restrictive clauses"
(1968:172). Coker & Umeda claim that "the pre-pausal pitch glide signals
the future direction of the sentence. A downward glide signals end of the
sentence; a weak rise indicates continuation, much in the same direction;
strong rise signals continuation with some change in thought. Pre-pausal
inflections occur on the last vowel, nasal or liquid before the pause"
(1971:139).

In addition to occurring at major syntactic boundaries, CRs also mark
'listing' types of co-ordination, including co-ordinated words, phrases, and
clauses: "when a list is given as a series of rising tunes ending with a
falling tune, the list is complete, whereas when the last group [also] has a
rising tune, the list is incomplete" (Hirst & Ginesy, 1974:49), as was the
case with the alternatives vs. examples questions (see 6.1.2.4). "When a
sentence is composed of a series of constituent sentences, the constituent
sentences are each assigned a rising tune except for the last one which is
assigned a falling tune"; thus if an utterance continues after a Tune I
terminal fall, the ensuing speech constitutes "an afterthought" (49, 48;
Lee, 1956:349), or possibly a type of "hesitation phenomena" (Nickel, 1970:
674). Isačenko & Schädlich claim that lists can be uttered with falling Fo
on each element, "which expresses emotional connotations" (1970:48); how-
ever, such examples usually involve sharper Fo falls with smaller CRs.
6.3.4) Two Types of Continuation Rise

Delattre distinguishes two types of Fo continuation patterns: a "major continuation," with an actual CR, and a "minor continuation," in which Fo levels off after a less steep fall, with ensuing Fo neither rising nor falling as low as in Tune I (1965:25, 27), although 't Hart & Cohen "have not found clear evidence for the necessity to distinguish between the so-called major and minor continuation" (1973:313). Daneš notes that "the segmentation of the utterance into sections is hierarchical," and that successively smaller portions of an utterance "may be subdivided by means of junctures of 2 or 3 different degrees," which are "differentiated by the form of the intonation contour and by the length of the bounding pause" (1960:45). Presumably, the Fo role in his "juncture" is that of the CR, since CRs between larger sections of speech involve larger Fo rises. Referring to Delattre's 2 types of continuation, Bolinger notes that "a greater or lesser breadth of [Fo CR] movement may establish a hierarchy of importance," with larger rises marking more important breaks, such as in Table 104 (1964b:26; Lee, 1956:358).

As illustrated in Table 21, there appear to be two types of CR, where the normal one starts from a low Fo level after a substantial Fo fall (#1 & 5) and the other one starts from a high level without a prior Fo fall (#2, 3, & 6). In #2-3 for JA's speech, instead of Fo falling and then rising, Fo on "car" rose directly +23 Hz without a prior fall (e.g., without a -27 fall, as in #1). This CR from a high Fo level appeared to be an optional variant on the normal CR pattern, which could only be used when there was redundant information in the conjoined structure. It was used here when "car"
in the first NP was followed by "car" or "one" in the second NP, but not when "blouse" occurred in the second NP instead.

Thus the 2 types of CRs are likely related to 'new/cld' information factors. In #1, the nouns in the 2 NPs were different ("car" and "blouse"), and the normal CR pattern occurred. In #2-3, however, the 2 nouns refer to the same concept ("car"). The speaker in this latter case apparently anticipated the redundancy in "car," and eliminated the fall in Fo that occurred in a similar location in #1, so that the CR in #2-3 started from a high Fo level rather than a low one. The falling Fo in "car" in #1 marked it with a degree of accent that "car" did not get in #2-3, because "car" in the latter case merely continued the rise started during the prior word "red." Thus, "car" occurring in both NPs in #2-3 did not receive primary accent in either NP. A similar analysis holds for "Cadillac" in #5-6 ("He bought a Cadillac mirror and a Cadillac tailpipe"); in #6, the +48 CR on "mirror" started from a high 150 (after a small +2 rise on the AS). Here, however, the repeated word was the modifier, not "mirror"; thus, these CRs can occur on unpeated words in a co-ordination which contains repeated words.

When repeated words occur in the same sentence, especially in short sentences such as the current ones, the speaker apparently can anticipate the later occurrence(s) of the same word, and utter all cases of it with lesser accent, in order to reserve accent for the non-redundant words in the sentence. Since this pattern requires a type of anticipation on the speaker's part, in noting that the first occurrence of a word will be made redundant by
the later context, it might be found more often in spontaneous speech, where the speaker knows what he is about to say, than in read speech, where the reader-speaker often only performs a limited look-ahead.

The Fo rise on "car" was classified as a CR, and not as an accent rise, for 2 reasons: it occurred immediately after an accent rise of larger size (+43, vs. the +23 CR) (Since primary accent is marked by the initiation of a rise or sharp fall in Fo, the continuation of such a rise or fall on an ensuing word does not mark the latter as accented unless that latter rise or fall is much larger than the former), and, more importantly, most of the rise occurred late in the syllabic nucleus. While the typical CR on an AS occurs late in the syllable, the accent rise invariably starts before or at the beginning of the AS. This 'marked' CR pattern is apparently optional, because it was not utilized in #4-5, even though "car" and "Cadillac" were repeated there in circumstances similar to #2-3 and #6.

Monotonic CRs also tended to be associated with quantifiers like "both." In Tables 130-131 ("Joe has (both) won the race and left the city" and "He drinks coffee (both) with meals and on the run," respectively), cases #1 without "both" had RF CRs on "race" and "meals" (averaging a -41 descent to 123, and then a +22 CR). With "both" (#2), "race" and "meals" had no descent, instead having only rising Fo throughout (a +23 CR, from 161). Thus, when "both" preceded the conjoined phrases, a monotonic CR was used. The use of "both" is similar to a redundancy situation in that it implies a common thread to the co-ordinate structure; unlike the other examples above,
since "both" precedes, there is no need for anticipation of redundancy by the speaker. Hence, the use of a monotonic CR should be required (not optional) with a prior "both."

Bolinger distinguishes these 2 types of CRs, saying that the FR form is the "more nearly neutral shape in American English," which "is particularly noticeable when unaccented elements are added after the accent," such as in compounds at the end of a clause; but that CRs consisting of "simple rises" also occur in English in "gnomic expressions like 'Easy come, easy go!'" (1972:27-28). Bolinger finds that the FR CR "is used when the speaker intends the first clause to be viewed as a new idea," while the monotonic CR is used if the first clause "only repeats what has gone before" (such as in an answer which repeats a clause from a preceding question): (1972b:155; see however 't Hart & Cohen, 1973:326). It seems then that a non-terminal clause or phrase which is entirely old information (and this includes well-known idioms) uses a monotonic rise, while normal units use the FR CR. It appears that the 2 CRs are not so much different in function as they instead immediately follow different Fo patterns: when the initial syntactic unit provides new independent information, Fo falls on it, enabling the FR CR form, whereas when the unit yields some redundant information (as in #2-3 & #6, or in gnomic expressions), Fo may avoid an accent-marking fall, with the CR starting at a high Fo level instead.

After "both," the use of the monotonic CR is probably related to syntactic cohesion, in that "both" 'binds' the conjoined phrases in such a
way that a sharp Fo descent in the middle is not allowed. Without "both,"
a break there is permitted; with it, Fo remains high until the end of the
scope of "both."

6.3.5) Summary

A CR is often used in the latter portion of the last syllable of a non-
final syntactic phrase to signal to the listener that that particular phrase
is over but that more utterance is yet to come. There are 2 types of CR:
the more frequent fall+rise CR, which contrasts with a Tune A fall, and a
monotonic CR, which has no prior fall. The monotonic CR was limited to cer-
tain contexts; it was used: in a list of phrases containing redundant infor-
mation in the co-ordination, in a list of single words, and in phrases
within the scope of a quantifier. In the first 2 situations, it was optional,
and its use was likely related to the expenditure of less effort (less Fo
movement with a monotonic than a FR CR).

The occurrence and size of a CR was governed by 3 factors; they oc-
curred (and were bigger): at 'stronger' syntactic boundaries, between longer
phrases, and before important new information. Thus, clause boundaries
(especially with parallel clauses and embedded clauses) had the biggest CRs.
Clause-internal CRs occurred most often in final clauses, at the highest
boundary in the surface structure tree, with the restriction that the
clause be relatively evenly divided. There was a trade-off: if the subject
NP was bigger than, or of comparable size with the VP, the NP-VP boundary
received a CR; if the VP was bigger, the CR occurred at the major boundary
within the VP. A list of 3 or more phrases received CRs at the ends of all but the last: FR CRs were used if each phrase had 2 or more words, monotonic CRs if less. Clauses with 5 or more content words invariably had a CR; clauses with 9 or more content words had 2 or more CRs. In multi-clause utterances, final clauses had more CRs than non-final clauses.

6.4) Offset Transformations

6.4.1) Definitions

Besides passive and focus transformations discussed in 5.3, there is another group of syntactic transformations, which can be classified as having a delimiting or offsetting function, in that each causes a syntactic phrase to be offset (to initial or final sentence position) from its original location. The ones that move a constituent to the front (called 'fronting' transformations) have a moderate focussing effect, but serve the more direct function of offsetting a phrase from the main body of the sentence:

1) **Topicalization** removes a phrase from the sentence, and places it in initial position (e.g., "The carrot a farmer was eating").

2) **Left dislocation** removes a phrase from the sentence, leaving a pronoun behind, and places it in initial position (e.g., "The carrot, a farmer was eating it").

In both cases, the removed constituent is placed in sentence initial position, with no insertion of any new function words (except possibly a pronoun 'trace') to make the transformed sentences 'smooth'; thus the resulting sentences have major syntactic boundaries between the fronted constituent and the rest of the sentence (indeed, the speaker often pauses
here (Hutchins, 1975:110), and a comma often marks the written versions
of these sentences). Of the two, topicalization is the more common, and
the rarer left dislocation can be viewed as a 'stronger' version of
topicalization.

The 'backing' transformations move a syntactic constituent to the end
of a sentence, with a de-emphasizing effect on the offset phrase:

1) Right dislocation removes a phrase from a sentence, leaving be-
behind a pronominal copy, and places it at the end of the sentence (usually
with a comma intervening in the orthographic version) (e.g., "He was
eating the carrot, the farmer").

2) Extraposition moves a sentential subject to the end of the sentence,
leaving behind "it" in initial position (e.g., "It is true that fish is
tasty").

These offset transformations are similar in operation to the focus trans-
formations in that they move constituents in sentences; however, these
appear to have some functions other than simple emphasis of a phrase. The
left offsetting transformations place the moved constituent into an explicit
'topic' position at the start of the sentence, and note the difference by
placing a clear Fo break at the end of the offset phrase. The right-
offsetting transformations move a constituent to final sentence position to
de-emphasize it, with a concomitant reduction in Fo accent and a clear
break before the offset constituent.
6.4.2) Left-offsetting Transformations

In comparing a passive sentence ("This flounder should be cooked carefully" - #1) with a topicalized sentence ("This flounder you should cook carefully" - #2) and 2 similar sentences with left-dislocated NPs (e.g., "This flounder, it should be cooked carefully" - #3), few differences in the accent pattern were found (Figs. 119-121). There was an overall small increase in the peak levels in the offset examples (#2-3) over #1 (averaging +4 on the content words), but no clear focus effect.

Significant differences could be seen on "flounder" after the accent peak, however. The descent in "flounder" was -19 bigger in #2 and -29 bigger in #3, than in #1. In addition, the CR at the end of "flounder" was +9 in #2 and +24 in #3, compared to only +4 in #1. In the offset cases, "This flounder" received enhanced status as a separate syntactic unit due to the offset transformation, and, as a result, Fo fell more sharply on "flounder," to mark the end of the phrase. The presence of the increased CRs can be attributed to the nature of fronting transformations: rather than focus on a set of words, they caused the resultant sentence to separately name the topic (the offset words) and then make a comment about it. Thus the information after the offset unit was clearly important to the message of the sentence, and hence an enlarged CR was used by the speaker to herald the comment. The Fo marking was more pronounced for dislocation than topicalization, because it can be considered the 'stronger' of the two.
6.4.3) Right-offsetting Transformations

In comparing a basic, active sentence ("You should carefully cook the flounder" - 133, #1) with 2 similar right-dislocated versions ("You should carefully cook it, the flounder" - #2; "You should cook it carefully, the flounder" - #3), the de-emphasis of the offset words "the flounder" correlated with a raising of Fo on the rest of the utterance: "carefully" and "cook" averaged +4 and +14 higher peaks, respectively, as well as having bigger accents in the dislocated versions than in #1, whereas "flounder" had a -9 lower peak (Figs. 122-124). Also, the offsetting nature of the transformation caused Fo fall off rapidly just before the offset point: the descent on "cook it" in #2 was -65 (plus a -10 fall on "it"), compared to only -27 on "cook the" when the ensuing phrase was not offset. Similarly, the descent on "carefully" was -51 (plus an ensuing further fall-off of -28 in the last 2 USs) when it immediately preceded the offset phrase. These deep Fo falls just prior to the dislocated phrase marked clear syntactic boundaries and delimited the ensuing phrase from the main portion of the utterance. Furthermore, the falls went below the BOR and no CR was used to signal the ensuing offset phrase; in short, the Fo contour before the right-dislocated phrase was the same as that at the end of an utterance. Hence, a description of the offset phrase as an 'after-thought' is appropriate, as it occurs after the 'end' of the utterance.

Treating the offset phrase as virtually a separate utterance may account for the increased accent on the remaining words in the utterance via a competition effect: the de-accenting of the offset phrase decreased the accent competition for the other words and hence increased their accent.
A similar type of right-offsetting was found in sentences whose verbs take 2 complements. "I find skiing downhill exciting" (134, #1) and "I find it exciting skiing downhill" (#2) differ only in the order of the final constituents. The former can be considered the basic case, and the latter as having moved the first complement to final position. The Fo effects of this movement were similar to right-dislocation, but less dramatic. The peak pattern for "... skiing downhill exciting" was 144-134-129, and for "... exciting skiing downhill," 152-118-108. Thus, there was a larger initial peak (as well as a larger drop-off after that peak) when the moved phrase followed. Whereas only one speaker (KS) had a small (+6) CR before the offset phrase in #2, two (JA and KS) had larger (+11) CRs at the end of "downhill" before "exciting" in #1. Thus, the CRs tend to be small or non-existant before right-offset constituents in general.

Similar effects occurred in extraposition ("It's true that fish is tasty" (84, #3 and Figs. 94-95). Having a function similar to right-dislocation, extraposition de-emphasizes a sentential subject by moving it to the end of the sentence. Accordingly, the content word of the fronted matrix clause ("true") received a large accent, whereas the embedded clause was reduced in accent. The peak pattern was 169-128-131 in #3, compared to 175-157-153 in the untransformed version (#2). Where the peak drop-off was only -4 between clauses when the matrix clause was final, it was -41 when the embedded clause was last. In addition, only one speaker (JA) had a CR at the end of the main clause in #3, and it was a very small one (+2 Hz) compared to his +26 CR at the end of the embedded clause in #2.
6.4.4) Other Offset Phrases

Many sentences have offset or 'parenthetical' phrases, which (similar to right-offset words) are less important than the rest of the utterance. In Table 135 ("There are many books I know that are worth reading"), #1 had no commas and #2 placed commas around "I know." Thus, in #2 (but not #1), "I know" functioned as an offset phrase. As a result, "books" had 36 more descent, the peaks in "I know" were -38 lower, and the CR on "know" was +17 larger in #2. The rest of the utterance showed little Fo difference; hence, "I know" received less accent and was marked by larger Fo breaks when it was used as a parenthetical phrase.

"I know" can be used as an offset phrase of importance, however; in Table 136 ("I know Joe was in error"), "know" got similar accent without (#1) and with (#2) a comma after it. Here the only major difference the comma made in offsetting "I know" was to place a +30 CR at the boundary (vs. no CR in #1).

Adverbial and adjectival phrases occurring at the start or end of a sentence can also be considered offset phrases. In Tables 137-138 ("Marcia paced back and forth 2" and "Peter was playing pool 2", respectively), the adverbial "the whole morning" (in 137:1-2) and the adjectival "unaware of the danger" (138:1-2) were placed in positions #1 or #2. As in offset-transformations, the offset phrases here ended with a (+14) CR in cases #1, but were preceded by no CR in #2. Also, the accents in the right-offset phrase (#2) were lower: the differential between the
average peaks in the left-offset phrase and the main clause was -39, but between the main clause and the right-offset phrase, it was a larger -56.

Lastly, offsetting a final clause, as in Table 139 ("Joe grew cotton to make money"), led to lower accent there. With no comma after "cotton" (#1), "cotton" ended with a +9 CR; with a comma (#2), it had a bigger accent (+12 more rise accent, +5 higher peak, 14 more descent) than in #1, and lacked a CR (with Fo falling below the BOR). Also, "make money" had -10 lower peaks in #2.

6.4.5) Summary

The major Fo effect of the offset transformations and phrases was that the offset constituents formed separate syntactic units, which were heavily marked in Fo through the use of sharp Fo falls, marking the end of a fronted unit in one case and the end of the main portion of the utterance before a backed unit in the other case. These transformations create separate syntactic constituents whose boundaries must be marked in Fo, as opposed to other syntactic breaks which are often less radically demarcated with Fo.

The left-offsetting cases serve a function similar to pseudo-clefting in that neither the fronted constituent nor the rest of the utterance loses much accent. The concepts of topic and comment are explicitly separated into different syntactic units, and as such, these units are well delimited via Fo falls right before the boundary between the two phrases of the
utterance. In each case that the topic preceded the comment, the importance of the ensuing words was emphasized through the use of a CR just before the break. The size of the CR, as well as the amount of the prior Fo fall, appeared to depend on the 'strength' of the boundary. 'Smooth-flowing' utterances (such as those with pseudo-clefting) had less dramatic Fo variations while the fronting transformations (especially left dislocation) performed a more explicit and abrupt division between the topic and comment, which was accompanied by larger Fo movements.

In contrast, the right-offsetting transformations had a distinct de-emphasizing function in addition to the delimiting function common to all offsetting operations. Besides the accent loss in the backed constituent, the Fo pattern at the boundary preceding the offset phrase noted the lack of importance of the ensuing words by having little or no CR to herald the offset phrase. In addition, in right dislocation, Fo at the end of the main sentence fell below the BOR, just as at the end of an utterance; in this context, the ensuing offset words can best be viewed as a form of 'afterthought' (Gruber, 1967:48).

6.4.6) Discussion

Langacker claims that the fronting transformations "have the effect of altering the relative prominence of constituents," and "serve to make the objective content of sentences more prominent" (1974:649-650). Halliday notes a similarity in function between the topicalization and passive transformations, but claims that the passive is"the preferred form unless the
actor is required to be overtly specified but non-focal in the clause," and that "modern English favors the passive... because... the passive allows the actor to remain unspecified or, if specified, to occur at the end of the clause and thus carry information focus" (1967a:11; 1967b:218). As further evidence of the similarity of passive and topicalization, neither transformation altered the Fo accent pattern significantly, and furthermore the use of one of these transformations would normally preclude the use of the other, i.e., topicalized passive sentences would sound "distinctly unusual" (Hutchins, 1975:113).

Lakoff refers to left dislocation as a "preposing of topics" and a "special device for indicating what is under discussion" (1971:236). "In general it serves as a means of isolating the theme from the remainder of the clause, since the theme is then not required as a participant in the clause structure" (Halliday, 1967b:241). Sentences like "Our car - it broke down" have "two primary accents, splitting the utterance so as to make both items informative" (Bolinger, 1957b:311). Gundel notes that, like clefting, "a left dislocated sentence... always answers some implicit or explicit questions--what about x, where x is the dislocated noun phrase," and that "the dislocated noun phrase is the topic of the sentence. Its function is to identify the object or set of objects that the sentence is about" (1975:106, 84). "The topic... never carries the primary stress in the sentence. In English... the constituent with primary stress always represents the new information." However, "while... dislocated noun phrases in general may never have primary stress... they are
never completely unstressed either" (1975:78, 104).

Langacker claims that "the primary function of the . . . backing rules appears to be stylistic," and with regard to extraposition especially: "They enable the speaker to avoid the awkwardness of having a heavy constituent early in the sentence by shifting it to the end." "The function of these rules is not to increase the prominence of the postposed constituent . . ., but rather to get it out of the way." So fronting and backing rules have opposing functions: "... fronting renders [the moved constituent] more prominent, while . . . backing decreases its prominence" (1974:644, 653). Right dislocation "reverses the normal sequence of theme-rheme," and "the meaning is, as it were, 'first I'll say what I have to say and then I'll remind you what I'm talking about'" (Halliday, 1967b:240).

6.5) Deletion Transformations

One form the expression of new/old information can take within a sentence concerns the deletion of old words. 'Ellipsis' involves the optional deletion of anaphoric units in a sentence. Often in a multi-clause sentence, some words are repeated in similar syntactic positions in successive clauses. If the syntactic structures are sufficiently parallel, all but one of the occurrences of the repeated words may be elided from the sentence with no loss of information (e.g., "Joe liked the cake, and Sue the salad"). Ellipsis deletes only predictable words from the sentence, since the elision of unpredictable words would cause a loss of information. For sentence material to undergo "an optional transformation by ellipsis,
the information deleted must be recoverable" (Hirst, 1:74:8). Bolinger notes that "it is often possible to omit the . . . destressed material with little loss of information" (1958b:77; see also Vanderslice & Ladefoged, 1971:12; Nickel, 1970:673). Roccric-Alexandrescu suggests that, using the intonation of the early part of an utterance, the listener can, to some extent, "'predict' the elements which will follow": "The intonation of the first part of the statement 'suggests' only the melodic units which are to complete the contour. By these means, also the elliptic constructions may be understood" (1970:772).

Since ellipsis deleted old, unaccented words, it had little direct effect on the Fo contour besides eliminating the parts of the Fo contour on the elided words. However, certain modifications did occur in the VP Fo when the main verb was deleted, leaving behind an aux. Such a remaining aux (usually unaccented) received an increase in accent in the elided utterance, which served to mark the ellipsis site. "Auxiliaries are stressed when they are followed by deletion sites," (Baker 1971:171). Related to ellipsis is auxiliary contraction, in which an unaccented aux drops its vowel and merges with the preceding word. Contraction is only allowed if no information will be lost; in particular, "it is impossible to con-tract emphasized auxiliaries" (175).

6.5.1) Gapping

Among the types of ellipsis, 'gapping' (deletion from the middle of a clause) had more extensive Fo effects than did deletion from the beginning
or end of a clause. It is perhaps more expected by a listener that old words would be deleted from the exterior of a clause than to have the clause broken up by an interior ellipsis. Tables 140-142 show different examples of gapping: the verb "ran" was elided from the second clause of "Joe ran the race, like Bob ran his lawn mower" in Table 140 and Fig. 125; the verb "studied" was elided from the second clause in the sentences "John studied Mary, and Bill studied Jane" and "John studied with Mary, and Bill studied with Jane" in Table 141 and Figs. 126-127; the verb "bought" was deleted from the second and third clauses of "Joe bought a chair, Sue bought a carpet, and George bought three beads" in Table 142.

Unlike other transformations, the Fo effects of gapping were mostly local and did not result in major alteration to the accent pattern. In the 2-clause cases of gapping (Tables 140-141), the peak patterns were very similar: for Table 140, the unelided and elided cases #1-2 had respective patterns of 155-131-120-117 and 153-127-117-119; for Table 141 they were 155-128-130-121 and 155-130-122-126. The only consistent differences here were that, in the second clause (which had the 'gap'), the first peak (before the gap) was -6 lower and the second peak (after the gap) was +4 higher in the elided versions. These differences are likely related, not specifically to ellipsis, but to a separation effect: after gapping deleted the verb, the 2 ASs were closer to each other, which tended to bring both Fo peaks closer to a common level.

On the other hand, in the 3-clause case (Table 142), where the verb was
gapped from the last 2 clauses, the Fo peak pattern was reduced overall by about -9 Hz in the elided version: 152-136-152-136-130-127 vs. 144-132-142-123-123-117. On a basis of this limited sample, one could speculate that Fo is reduced in gapped sentences of more than 2 clauses, perhaps as a correlate to the anticipation effect.

The other Fo differences due to gapping were not consistent across speakers, and indeed even across utterances of a single speaker. JA had a tendency toward having a greater Fo fall on the AS preceding the gapping site: the word preceding the last gap in each elided utterance averaged a -28 fall compared to a -9 fall in the unelided utterances. This led to a rise+fall pattern on the one-word subject, which ordinarily is too short to receive both the sharp accent rise and fall of a P-unit; but apparently (in some circumstances) the deletion of the ensuing verb is sufficient motivation that the speaker notes the unexpected close of a unit, to help signal the gap. However, KS and DO did not follow this pattern at all, and JA used a reverse pattern at the first gap of the double-gapped sentence (142:1-2). One consistent pattern was that a +14 CR preceded the gap in the sentence "John studied Mary, and Bill, Jane"; however, this was the only case of a CR at a gap and undoubtedly occurred because of the comma there (commas were not used at the other gapping sites).

While not all of the gapping examples here exhibited large Fo changes at the ellipsis sites (although one of the examples had a very pronounced Fo pattern, with a rise+fall+rise on the word preceding the ellipsis (#2)),
they all displayed accent on the word preceding the gap, even where the word in the unelided version was unaccented. All cases also exhibited minimal changes in Fo except at the ellipsis site; thus the Fo effects of gapping can be considered local.

In eliding old information words, gapping deletes that portion of the Fo contour which had occurred on the removed words. Since the presence of these words was not of major importance to the utterance message in the first place, they did not have major accents in most cases, and the deletion of this section of the Fo pattern had only local effects on the contour. The major Fo differences were those of accenting the word preceding the gapping site and of sometimes marking the site as a syntactic boundary via an Fo fall on the preceding AS. These differences apparently help to signal the listener that words have been removed from the utterance. By marking a syntactic boundary in Fo at a location (i.e., the gap) which, without the ellipsis, would not be considered for an Fo syntactic marking, the speaker can call attention to that location and signal that words have been removed.

Gapping has been referred to as a "deletion rule . . . whose principal function probably is simplification," "to simplify surface structures by removing 'deadwood' in the form of 'redundant' lexical material" (Heath, 1975:100). Such deletion rules serve "to increase the prominence of objective content" (Langacker, 1974:657) by deleting competing redundant information. That the syntactic "constituents left over after application
of gapping necessarily represent new, unpredictable information" (Kuno, 1975a:28) can be related to the accenting of the word preceding the gapping site (1975b:174), since that word represents new information.

6.5.2) Other Types of Ellipsis

Another form of ellipsis in 2-clause sentences deletes repeated words from the beginning of the second clause. Table 143 concerns a set of sentences based on "George relies on his business friends, and he also relies on his social friends" (#1). In #2-5, one or more words were deleted from the second clause: "he" in #2, then "also" in #3, then "relies" in #4, and then "on" in #5. From #4 ("George relies on his business friends and on his social friends"), the words "friends" from the first PP (#6) and "on his" from the second PP (#7) were successively elided also.

Among JA and KS (the 2 speakers who recorded all of #1-3), the deletion of "he" in the second clause led to a -10 decrease in the Fo peak on the ensuing "also," and to a +6 increase on the peaks of the other 4 accented words in the utterance. The presence of "he" in the second clause in #1 marked the sentence as having no ellipsis; "he" was the most 'unnecessary' or redundant word in this sentence; unless special emphasis is being made of the parallel nature of the 2 clauses, usually one or more redundant words (if present) will be elided. Thus, in #1, which had no such elision, the word "also" apparently took on the role of stressing (via a large accent) the similarity between the clauses. When there was some ellipsis (as in #2), "also" became relatively less important and decreased in accent.
The successive deletion of "also" led to no peak change in the first clause, but to a +14 peak increase on "relies" and a -16 peak decrease on "social" (both in the second clause). This was clearly a separation effect: the deletion of the accented "also" allowed the adjacent "relies" to regain 'normal' accent, which in turn decreased accent on the ensuing "social."

None of these deletions apparently had much effect on the CR at the end of the first clause, which was +29, +23, and +27 in #1-3, respectively; the presence (#1-2) or absence (#3) of a comma seemed to have no major effect either. As long as the 2 clauses each had a full VP, the CR was approximately +26 (for JA and KS). With DO's results averaged in, it was +23, compared to +12 when the verb was deleted (#4-5) and only +4 when the first "friends" was also elided (#6-7). In #4-5, the syntactic boundary was between 2 PPs or NPs ("(on) his business friends and (on) his social friends"), and in #6-7, the boundary lay between even smaller constituents ("(on his) business and (on his) social friends"). Again, larger constituents led to a larger CR at the break between them.

Although the accent peak on the initial word ("George") did not seem to vary with different amounts of ellipsis (in #3-7), the peak on the final accented word ("social") increased with more ellipsis: 116 in #3, 120 in #4-5, and 126 in #6-7. This increase was likely due to a competition effect, in which the deletion of a preceding content word (e.g., "relies" and "friends") enabled "social" to rise in accent.
Another accent pattern variation was that the peak on "business" went from 143 in #3 to 148 in #4 & 6 to 137 in #5 & 7. Whereas an accent peak after an ellipsis site can be expected to increase as more words are deleted (as happened with "social"), a peak before the site should decline, as per the anticipation effect. However, in #4 & 6, the peak increased instead. This situation is similar in analysis to that of the large accent on "also" in #1: in both cases, there were redundant function words ("he" above, "on" here) which could have been elided but were not. These 'marked' situations apparently led to increased accent on words which emphasized the parallel nature of the syntactic structure. In this set, "business" and "social" were the 2 contrasting words in the co-ordinate structure; and in any parallel construct, the first element gets more increased accent than the second. Thus, "business" had higher peaks in #4 & 6; in the other cases, the peaks were lower either because no further ellipsis was allowed (as in #7) or because the next logical word to be elided was a content word (as in #3 & 5).

Thus, the effects of ellipsis from the beginning of a clause appear to be limited to those of variations in accent peaks and CRs. Perhaps because this type of ellipsis leaves 'gaps' only at points of conjunction, which ordinarily mark syntactic boundaries, no other consistent changes in Fo patterning were found related to this type of ellipsis.

6.5.3) Verb-phrase Deletion

In VP-ellipsis, a 'verb phrase' is deleted from one or more clauses in
a multi-clause sentence. Usually the main verb along with its direct complements (rather than the entire VP) is deleted. In Table 144 and Figs. 128-129, the phrase "buy it" was elided from "Robert hasn't bought the car yet, but he will but it later today"; and in Table 145, "drive(n) to the store" was deleted in all except either the first or last clause of "Robert might drive to the store, Sharon has driven to the store, and George will drive to the store."

In these cases of VP deletion, the main effect on the remaining Fo contour was increased accent on the aux preceding the ellipsis site. In Table 144, the accents on "Robert," "car," "later," and "today" all varied less than ±2 Hz with vs. without the ellipsis; but the peak on "will" in the elided case (#2) was +11 higher than that on "will buy" in the unelided case (#1). In addition, the rise accent and fall accent on "will" were +19 and -14 larger in #2.

Similar results were found for the aux's preceding ellipsis sites in Table 145. In the middle clause ("... , Sharon has,..."), "has" averaged a +22 rise and -38 fall accent, which provided a large accent for an aux. For the first clause ("Robert might (drive to the store)"), in the elided version, "might" had +13 more rise accent, +16 higher peak, and -24 more fall accent (as well as decreasing the accent peak on the prior "Robert"), than in the unelided case. Similarly, in the final clause ("and George will (drive to the store)"), "will" had +6 more rise accent and a +3 higher peak in the elided version.
In addition to these accent effects, the ellipsis in Table 145 appeared to affect the clause-boundary CRs. In #1, where the VP was deleted from the last 2 clauses of the sentence, the CRs were +24 and +16, respectively, at the 2 clause breaks. In #2, where the VP was deleted from the first 2 clauses, they were only +7 each. This difference appears related to the need for a 'signal of non-finality' to the listener: in #1, the first clause constituted a grammatical sentence, and the lack of a substantial CR here could lead the listener to assume the end of the utterance; whereas in #2, the ellipsis in the first 2 clauses prevented such an incorrect interpretation on the listener's part, and thus less of a CR cue is needed.

Accent on the word preceding an ellipsis site was not restricted to content words or aux's. Among 12 different sentences with VP-deletion (e.g., "Joe felt hostile to, and afraid of, his neighbor") or with deletion from the start and end of a clause (e.g., "Joe walked into and through the sand") in Table 146 and Fig. 130, words in parallel positions (one preceding the co-ordination site and one preceding the ellipsis site) had increased accents. This increased accent in ellipsis is likely a parallel effect, rather than any effect particular to ellipsis.

In #1-3, there were 4-6 words between conjunction and ellipsis site, and the first break had a -86 descent and +50 CR, while the second had a +25 CR. In #4-7, there were only 2-3 words intervening, and the first break had a lesser -52 descent and +20 CR, while the second had a lesser +7 CR. In #8-10 (which lacked commas, unlike #1-7), there were 1-2 words intervening,
and the first break had a -48 descent and +14 CR, and no CR at the second break. In all #1-10, there was a relatively consistent -61 descent at the second break. Thus, longer phrases led to bigger descents and CRs; and among the shorter phrases, the presence of commas at the boundaries meant slightly larger CRs. Also, bigger breaks occurred before the conjunction than at the ellipsis site.

2 of the 5 utterances here that lacked commas (#11-12, e.g., "He totally baffled and utterly amazed me") displayed different Fo patterns: they lacked FR CRs at both boundaries, had only -38 descent at the second break, and averaged -13 lower peaks than in #1-10. Rather than having a sharp descent at the first boundary, these had no descent. Thus, when commas do not mark the ellipsis and only 1 or 2 words occur between conjunction and ellipsis site, the speaker apparently has the option to mark or not mark the boundaries with sharp Fo breaks.

In successive cases of Table 147 ("Robert might drive to the store, and Sharon might drive to the store too" (#1)), the following old words were deleted from the second clause: "to the store" (#2), "drive" (#3), and "might" (#4). "Sharon" was the sole new information in the second clause, and consistently got a +41 rise accent (and a -37 fall accent, with a 141 peak) when any redundant words followed (#1-3). In contrast, those old words had accents averaging only: +6 on "might," +7 on "drive," and +18 on "store." When all the redundant words were elided (#4), "Sharon"s accent was reduced (-6 less rise accent, -14 lower peak, 16 less fall),
probably because a large accent was not necessary to contrast the new word "Sharon" against the redundant words (as was the situation in #1-3).

A similar Fo effect appeared regarding the accent on the utterance-final "too": +50 (155 peak) in #1, +40 (142 peak) in #2, and +28 (129 peak) in #3-4. As more old words were elided, the 'need' for a large accent on the contrasting word "too" decreased. "Too" functioned in much the same way that "also" did in Table 143; it added no information of its own, but instead highlighted the parallel nature of the 2 clauses. It got its largest accent when the redundant words were repeated in the second clause for emphasis; since these 'old' words did not receive large accents, "too" acted as a carrier for the emphasizing accent.

No consistent Fo effects due to the ellipsis here were found in the first clause, other than a decreased CR at the clause boundary in #3-4 vs. #1-2 (+23 vs. +34 Hz). As above, the decreased size of the second clause in #3-4 was the likely cause of the shrinkage of the CR preceding that clause.

6.5.4) Summary

The deletion or 'ellipsis' of old words from a sentence led to mostly local Fo effects. Upon deletion of relatively-unaccented words, the phonetic effects of competition, separation, and anticipation caused smaller accents and smaller Fo breaks on the remaining words. The words preceding ellipsis sites tended to receive increased accents (even if
normally unaccented) because they formed parallel relationships with other words in the utterance. The deletion of a word from the middle of a clause ('gapping') sometimes led to an Fo break there to mark the gap. When words at the start or end of a clause could, but were not, elided, words conveying the parallel structure of the clauses (e.g., "too," "also") got increased accent. CRs frequently occurred at ellipsis sites, but their sizes were smaller than those between clauses.

6.6) Noun-phrase Structuring Patterns

Non-co-ordinated NPs containing more than one content word appear to indicate their syntactic structuring through a patterning of successive Fo levels. NPs with more than one content word usually formed P-units; the first content word had the biggest accent (with a large Fo rise and usually the highest peak in the NP) and the last content word had falling Fo, usually ending at the lowest level in the NP. Intermediate content words in the NP had Fo values which appeared to occupy medial 'levels' between the Fo peak of the first and that of the last.

Table 148 shows the peak patterns and surface structuring (or 'bracketing') for NPs from utterances in Tables 113 and 153-160. These NPs contained 3-7 content words, and exhibited several different bracketings. Comparing the peak differentials on successive content words: the 2 most closely-related words averaged a -19 differential, while the other pairs averaged only -9. For example, the bracketing for the longest NP was: "((Vermont (state government))(priority funding) (established guidelines)),"
Between "state" and "government," "priority" and "funding," and "established" and "guidelines," the differentials were: -12, -14, and -5, respectively; whereas the other paired peak differentials were (left-to-right): -4, -2, and -2.

With 5 exceptions out of 17 (which 5 averaged a -19 differential), the differentials crossing a parenthesis in the bracketing ranged from -11 to +7 (averaging -1). In contrast, with 3 exceptions out of 13 (which 3 averaged 0 differential), the peak differentials crossing no parentheses averaged -24. 4 of these might be classified as compounds (e.g., "at first sight," "polar bears"), and they had the biggest differentials (averaging -37); the remaining 6 ranged from -19 to -12 (averaging -16).

Thus there was a definite tendency (although there were several exceptions) for the peaks on successive content words in a NP to remain at the same Fo level, dropping substantially only when that word-pair formed a syntactic unit. In other words, the biggest peak differentials occurred between the first 2 peaks of a left-branching structure, and the last 2 peaks of a right-branching one.

Within a P-unit, such as that encompassing a simple (non-coordinated) NP, Fo motions are somewhat restricted: the first AS has an Fo rise, and the last one concludes with Fo falling. However, the Fo movements of the intermediate words are allowed to be either rising or falling (usually a smaller rise or fall than those in the external words); i.e., the content words follow the bracketing pattern above in terms of how the Fo
peaks are arranged, but Fo is then free to rise or fall during the PA word.

The implications of these findings for an Fo-by-rule algorithm is that, in addition to specifying how big an accent each content word might have (based upon other syntactic/semantic phenomena), one must have (at least in non-coordinated NPs of 3 or more content words), a simple bracketing pattern to indicate how much the Fo peak on a given word should drop.
7) **Phonetic Effects:**

7.1) **Global Patterns**

7.1.1) **Declination Lines**

7.1.1.1) **Reference Lines and the Carrier Effect**

Before a judgment can be made as to how much the Fo pattern on an AS deviates from a 'normal' contour, a prototype or guideline pattern should be obtained, against which Fo accent shapes can be compared. Perhaps the best way to find such a basic pattern would be to average parameters of the Fo curves over a wide set of utterances. Table 149 illustrates the average values for successive peaks and valleys in all the Fo contours in set G (for JA). The utterances (all Tune A) were divided according to the number of sub-contours (SCs) each had, and the highest and lowest Fo values in each SC were designated as the peak and valley of that SC.

Of major note in Table 149 is the general declining trend for both peaks and valleys as the utterance progressed. In particular, the highest peak in each case was the first, and the lowest was the last. This declining pattern formed the 'carrier,' in which later ASs had lower peaks and smaller accents.

Among the Fo patterns in 1-clause utterances (#1-5), most had 2 SCs with the second peak averaging -38 less than the first (174 - 136 Hz). A sizable minority had 3 SCs, in which the second peak was -29 lower than the first and +18 higher than the last (179 - 150 - 132, respectively). The same general falling trend occurred in the longer utterances, but the
third peak tended to be somewhat higher than the second: with 4 SCs, the peak pattern was 190 - 161 - 167 - 140, and with 5 SCs, it was 184 - 154 - 171 - 159 - 143. The average drop-off per peak for the different cases was: -38 for 2 SCs, -24 for 3 SCs, -17 for 4 SCs, and -10 for 5 SCs.

The anticipation effect is reflected in Table 149, in that the initial Fo peak increased with the number of SCs in the utterance, up to a limit of about 190 Hz. Utterances with 4 or more SCs appeared to have the highest initial Fo peaks. Despite this increased Fo range, the per peak drop-off was smaller with more SCs. While the average initial peak ranged over 33 Hz (157 to 190) depending on the number of ensuing SCs, the final peak showed no dependence on the number of SCs (averaging 138+6 Hz in the cases with more than one peak).

The biggest drop-offs between peaks were the one after the first peak and the one before the last. Thus it is possible that, in the longer utterances with 4 or more SCs, the middle peaks occupy a 'middle ground,' with little Fo drop-off between them. In the absence of more extensive and controlled data, a linear drop-off among the peaks is likely a good model for the upper declination line.

A description of the trend of successive Fo valleys is simpler; the lowest valley was the final one (averaging 85 Hz) and preceding valleys exhibited a declining trend toward that final low value. Barring the
final valley, the average successive valleys were: 112, 106, 102, and 103 Hz. This drop-off trend, much lower and more gradual than that of the peaks, forms the lower declination line, being (for JA's speech) in the region of approximately 95-110 Hz (the BOR).

The first 'valley' of each Fo contour has not been included in the above valley trend because not all the utterances had initial USs before the first AS. In those that did, the valley averaged a relatively consistent 107 Hz; in those with an AS in initial position, Fo started the rise at an average of 126 Hz. The presence of initial USs had little effect upon the ensuing Fo pattern, and the number of SCs had no effect on the Fo of the USs.

The peak and valley trends in multi-clause utterances followed those in simple clauses with the exception of a 'resetting' effect, in which the trends or declination lines were 'reset' to a higher Fo level at clause boundaries. The underlined entries in #6-11 represent the initial peak values of non-initial clauses. In most of the cases, the declining Fo trends in both peaks and valleys were arrested at the boundary, and the decline started over again at higher Fo values. With the exception of the last clause in #10 (which had an abnormally large Fo peak on "quick," due to the parallel and unvoiced effects), the clause-initial Fo peak averaged +5 higher than the prior peak (this included the 3- and 4-SC cases of #6-7, which normally had large between-peak drops). The increase in Fo valleys across the clause boundary was even more consistent, averaging a
+11 Hz gain for all 7 cases; this increase reset the lower declination line from the bottom of the BOR to the top.

7.1.1.2) Discussion

The declination lines have been noticed in various forms by a number of authors (Adams, 1969:123; Nash, 1970:175; Isačenko & Schächlich, 1970:49; 't Hart, 1974:62): e.g., Bolinger thinks "such a gradual lowering of pitch is very common" in many languages, and may be a "language universal" (1964a:833). 't Hart & Cohen estimate "the slope of the declination line" to be 3% every 100 msec at the start of an utterance, with the rate dropping exponentially to 0.5% after 5 sec (1973:314; Collier, 1972:59); they note that the line provides "a way of relating up or down excursions to an average reference voice level," and relate the falling Fo line to the falling breath group shape (Cohen & 't Hart, 1967:187). Collier refers to the lower declination line as "the base line on which rises and falls are superimposed," while the high line "links a rise and a subsequent fall" (1972:57, 142).

Mattingly assigned the declination line a falling rate of "one semitone every 320 msec. The slope should certainly be no steeper than this and might well be less steep; a slope of Ø, however, gives an unnatural, droning effect" (1968:175). Lea & Kloker's system uses one (rather than two) "archetype line," constituting an exponential fall "extending from the maximum Fo point down to a point near the end of the constituent"; they look for ASs with Fo rising above this line (1975:14; Lea, 1973:29). For
Swedish, Carlson et al regard Fo contours "as the result of two superimposed effects: sentence intonation and stress marking," and refer to the "sentence intonation" as "a linear fall from 120 Hz to 90 Hz" (1972:16). Maeda found that, for two of his three speakers, the lower declination line "falls only at the beginning of sentences," whereas for the third, it "gradually falls throughout the whole sentences," but at a declining rate; in addition, "all speakers produce a rising of the baseline at each major syntactic boundary" (1974:206).

Other authors give data which are exemplary of the declination lines, without explicitly referring to the lines; e.g., McClean & Tiffany found in their study that "72% of initial stressed syllabics were higher in Fo than corresponding final stressed syllabics," and noted similar results for 82% of the "unstressed syllabics" (1973:286; Jassem, 1972:251). Similarly, McAllister's data (1972:968) show a gradual Fo fall throughout an utterance, and so he concludes that Fo values can be derived "by considering (1) the length of the phrase and (2) the position of the individual word in the phrase" (969).

7.1.2) Types of Accent

7.1.2.1) Basic Sub-contour

Fo accent can be regarded as that aspect of the Fo pattern by which certain syllables are marked for special attention. To achieve the objective of highlighting certain syllables in the listener's perception, the speaker apparently uses certain deviations in Fo from the normal pattern.
In ordinary speech, the most common deviation for accent purposes is the SC, an upward obtrusion among the gradually-falling Fo pattern (Fig. 3a). Each SC starts on an AS, but due to certain constraints, not every AS has its own SC. Factors such as speaking rate, spacing of ASs, preciseness of articulation, and syntactic structure directly affect the realization of ASs by SCs. Deviations from the basic SC include sharp, deep Fo falls and relatively-level (but slightly falling) Fo. The rises and deep falls can be considered as 'primary' accents, and the slight falls as 'secondary' accents, due to the differences in the relative abruptness of the deviation from the norm (see Fig. 3 b-c).

Fo in the SC starts at a medium-low level, rises rapidly on the AS to a peak, and then falls to a value lower than that at which it started. The shape of the Fo fall is roughly that of a 'dying' exponential, falling rapidly at first, then more slowly, and finally 'bottoming out' at a low level in the BOR. The Fo trajectory is relatively smooth, with at most one inflection point (where the shape goes from convex to concave). A typical Fo pattern in an US after an Fo peak of, say, 151 Hz would be a drop of -13 Hz to the start of the vowel and then a continued fall of -15 Hz during the vowel portion of the syllable. A number of factors affect the amount and shape of the fall, including: the number of ASs and USs in the SC, and the height of the Fo peak in the SC.

A few authors have observed patterns similar to the SC in their data; it is sometimes referred to as a "mid-high-low" pattern. (Mattingly,
Öhman's synthesis system uses a "humped" exponential shape as "the impulse responses of the word and intonation filters" (1967:21). Olive models the Fo for each word in his short utterances by a "fourth-order polynomial" which has the shape of a SC, where each pattern is determined by 5 parameters: the terminal minima, the peak, the durational location of the peak, and the final slope (1975:479). In describing the Fo used by speakers uttering the frame sentence "Say the word ____ again" with various monosyllabic words in the slot, Lehiste & Peterson note: "Both perceptually and physically . . . the precontour appears to form a middle intonation level compared to the highest and lowest levels that were observed on the test word" (1961:424).

Delattre refers to the SC as a "reversed-S' falling intonation which is so characteristic of American English" (1965:23), claims that "the falling portion of stressed syllables . . . bear the greatest intensity," and notes that Fo in USs is "low before and after the stress" (26). Delattre et al note that "the post-stress syllables . . . are generally . . . low in English" in Fo, and remark upon the "continuity" of the Fo curve after the peak (which differs from German) (1965:151; Shimaoka, 1966:358).

On occasion, the SC (or any Fo rise) "can be preceded by an anticipatory dip" in Fo (Cohen & 't Hart, 1967:185). This "short reverse pitch movement before a stressed syllable" (Peck, 1969:117) or "small drop in Fo prior to the rise . . . serves to accentuate this rise" (Atkinson, 1973:242).
7.1.2.2) After the Peak

The falling Fo pattern in USs is not confined to syntactical units. SCs can start on a noun subject, and continue through an aux and the first syllable of the main verb (if they are USs) (e.g., "is recorded"). Further, word boundaries after USs do not seem to affect this falling pattern; e.g., the first syllables of "perhaps" and "occasionally" (both USs) usually followed the same falling pattern as did the aux's.

Deviations from the basic SC, used to note secondary accent, were found on PA syllables such as verbs and A modals, which were not given primary accent because they occurred close to an AS. On the marked syllable here, Fo flattened out prematurely (i.e., well above the BOR) and exhibited considerably less fall. In this study, the most frequent occurrence of secondary marking was on those A modals not receiving accent (often because they were adjacent to a sentential adverb or "not").

This secondary Fo marking can be viewed as a SC in its own right, but much reduced or flattened. It is possible that the same physiological Fo gesture is utilized by the speaker to mark these syllables as to accent the more prominent ones; the only difference being that with the ASs, Fo was able to rise in full bloom, whereas in these secondarily-marked syllables, there was not sufficient speaker motivation or there were contextual accent restraints which prevented a full Fo rise from taking place.
This tendency of Fo in USs to 'fill-in' the regions between accent-marking Fo changes on the ASs indicates that the Fo contour is structured around the ASs, and that Fo patterns in USs follow directly from the contexts provided by the Fo accents. While the general pattern in USs is that of falling Fo (eventually levelling off in the BOR), the rate at which Fo falls and the level Fo occupies are completely dependent on the Fo context provided by the ASs. In most well-articulated speech, Fo in the USs invariably falls toward the BOR; but in P-units and in less well-articulated speech, the speaker avoids (for economical effort reasons) producing a separate SC for each AS, and attempts to convey the accentual information of 2 or more ASs by various modifications of one SC. Daneš claims that USs lack any "distinctive points" in the intonation contour, points which determine the contour's shape; thus, since Fo does not have to mark these non-distinctive USs, "the contours extend and contract like an accordion according to their segmental base," since the USs provide a "carrier" for the distinctive Fo movements (1960:39).

7.1.3) Bottom Ordinary Range (BOR)

The Fo region enclosing the lower declination line has been designated the BOR, since it is the Fo band to which USs return after accents. For the male speakers in this study, this BOR was located around 90-110 Hz, and was about 10-15 Hz wide. Parenthetical expressions and low-key 'monotone' speech, as well as USs in ordinary speech, have Fo which often resides in this BOR (Peck, 1969). Fo usually did not fall below the BOR until the very end of a Tune A utterance, when Fo fell to an utterance-minimum about
10-15 Hz below the BOR.

If enough syllables were present within a SC with only one primary AS, Fo 'bottomed-out' (i.e., levelled off) in the BOR during the USs following the AS. The amount of Fo 'room,' or the difference between the peak in the SC and the top of the BOR, had a direct effect on the amount of Fo fall during the first and second USs of a SC. Fo in these USs usually fell about 1/2 to 2/3 of the Fo distance remaining to the BOR. Roughly half of this Fo fall occurred in the drop prior to the nucleus and half during the nucleus of the US. Thus SCs with high Fo peaks had more rapidly-falling-Fo patterns after the peak than those with lesser peaks. But the end result was the same: within 2-3 USs, Fo reached the BOR and flattened out (unless Fo remained high in the USs in anticipation of the final accent fall of a P-unit, or the utterance was Tune B).

The BOR was the main Fo region for old information words occurring after all of the new words in an utterance. The last new word in each utterance had a falling accent, and the tail of its SC usually contained Fo for the remainder of the utterance. Any ensuing old words had small Fo rises and falls which did not leave the BOR (vs. Fo rising above the BOR on normal ASs). Typical Fo activity within the BOR (i.e., in the tail of a SC) involved PA syllables, which, not warranting an accent for reasons of context, had small Fo rises within the BOR to secondarily mark the syllables, and then had slight falling rates (up to -100 Hz/sec).
7.1.4) Summary

The global pattern of peaks and valleys in a Tune A utterance followed a generally-declining 'carrier,' after a high peak on the first AS. The respective declining rates of successive peaks and valleys formed upper and lower 'declination lines,' which converged as the utterance progressed. Thus, later peaks and accents were smaller than earlier ones (i.e., the positional or 'carrier' effect). Successive peak differentials on the upper declination line were largest at the start and end of an utterance. The declination lines were 'reset' to higher levels at clause boundaries.

Most ASs were realized in Fo by the initiation of a sub-contour (SC), an Fo obstruction above the lower declination line. After the AS, Fo usually fell at a roughly-exponential rate during the ensuing USs, bottoming-out in the BOR, a region around the lower declination line. Fo rose out of the BOR on ASs and fell below it only at the end of a Tune A utterance (and in special cases such as right dislocation). Some SCs contained a second AS, in which Fo either: fell sharply after some relatively-level Fo (as in a P-unit), or fell at a lesser rate than other adjacent USs (as in a secondary accent). The Fo falling rate in USs after the AS depended: on whether the SC formed a P-unit (where Fo fell slowly), and on the height of the Fo peak in the SC (Fo fell more rapidly from higher levels). Fo in USs essentially 'filled-in' the Fo contour between the sharp Fo rises and falls of the ASs, which basically structured the contour.
7.2) Local Accent Patterns

7.2.1) Anticipation

The Fo range used by a speaker (between 1 and 2.5 octaves (O'Connor, 1973:101; Adams, 1969:99), but usually limited to 1.5 octaves ('t Hart, 1974:62)) varies from utterance to utterance depending on a number of factors. One such factor is 'anticipation,' in which the speaker used a larger Fo range for longer sentences; he apparently 'anticipated' the greater number of ASs present in a longer utterance, and adjusted the initial Fo peak higher to accommodate the larger number of ensuing SCs (the bottom of a speaker's Fo range appeared relatively fixed, so the speaker must raise his maximum Fo to increase the Fo range in an utterance). McAllister claims that Fo behavior in an utterance is related to "the length of the phrase" (1972:969); his data show higher Fo values in utterances with more words following the examined ones (968). As Lieberman notes, "a speaker has an idea of what he is about to say and ... will carry out pitch movements at the beginning, anticipatory to those that are to follow" (Cohen & 't Hart, 1967:179).

In anticipation, the height of the initial Fo peak in an utterance depended upon the number of words and clauses it contained. However, the relationship between the initial Fo peak and the length of the utterance was complex. It is not simply a linear function of the number of words or syllables, because some utterances with widely different lengths had similar initial peaks. On the other hand, when several utterances of different lengths but similar initial words were compared, the initial peak
showed an essentially monotonically-increasing function with utterance length.

7.2.1.1) A Model

To account for this data, it is proposed that the initial peak increases in value in proportion to the size of the initial syntactic phrase (usually the subject) and to the number of 'phrases' in the utterance. These 'phrases' roughly coincide with the syntactic phrases of NP, V, PP, and clause, although the size of each unit (e.g., how many words in an NP) plays a role. Illustrating this in Table 150 are data for set G, grouped by syntactic pattern. #1-17 concern utterances in which the initial accented word was a single-noun NP; similarly, #18-25 show data for initial NPs of 2-3 accented words of the form Adj+(Adj)+N, and #26-27 for those NPs of 4-5 non-conjoined accented words. Examining #1-17 first, the basic case was a simple N+V sentence (#1) with an initial 152 peak; when a NP or PP was added (#2-3), the average peak increased to 162. If 3 'phrases' followed the initial noun (#4-12), the peak increased to 174 (the definition of 'phrase' is discussed further below); if 4 or more phrases ensued (#13-17), the peak averaged 187. Thus, from a base peak level of 152 Hz, each addition of the third, fourth, and fifth 'phrases' beyond the basic 2 phrases (of noun and verb) appeared to add about +12 Hz to the initial peak.

When the initial NP was of the form Adj+N or Adj+Adj+N, the basic case (i.e., a simple verb ensuing) had a 167 initial peak, which was +15 higher than that for a simple single-noun NP (cf. #18-19 with #1). As above, the
addition of more ensuing 'phrases' increased the peak value: 175 with 2 phrases after the initial NP (#20-22), and 184 with 3 or more 'phrases' following. Finally, for initial NPs with 4 or 5 non-conjoined accented words followed by 2 'phrases,' the peak averaged 186.

Thus a model of this pattern is: for a basic 2-phrase utterance with a single-noun initial NP, an initial peak of 152 Hz; for each additional 'phrase' (up to a total of 5), add +12 Hz to the initial peak. The addition of 1 or 2 accented words to the initial NP itself counts as one 'phrase,' and the addition of 3 or 4 as 2 'phrases.' The use of the term 'phrase,' to describe similar Fo effects in raising the initial peak by the addition of units of such disparate length as verb and clause, illustrates that mere utterance length in terms of words or syllables was not sufficient to account for the phenomena. The effects of anticipation appear strongest at the beginning of an utterance and weakest at the end. For example, the addition of "and"+N to the subject (#10-12, 16-17) had the same effect as the addition of a clause at the end of the initial clause (#6 & 13), viz., they both could be modelled as one *phrase* in that they raised the initial peak +11 Hz.

The insertion of "and" in the subject appeared to have a stronger effect than the mere addition of a word. In utterances with a subject NP consisting of single nouns conjoined with one "and" (#10-12), Fo ranged only +3 Hz in initial peak values, whereas the insertion of 1 or 2 extra "and"'s into the co-ordinated NP (#16-17) raised the peak by +10-13 Hz. Thus, a
subject of N+"and"+N+"and"+N had a higher initial peak than one with
N, N, N, + "and" + N.

A possible explanation for this model is that the speaker, before
commencing an utterance, gauges in approximate fashion how long the
utterance will be and adjusts his initial Fo peak accordingly, to allow
sufficient 'operating room' in the Fo range, so that Fo can fall-off at
approximately the same rate in utterances of different length, with Fo
ending in the BOR (which is fixed for a given speaker). This rough
approximation of the length of the utterance apparently utilizes the
number of 'phrases' as a measure, where the 'phrases' do not necessarily
correspond to major syntactic units (such as subject and VP), but more
likely to smaller units, such as verbs, adjectives, and simple MPs and
PPs; larger phrases consisting of smaller units separated by conjunctions
would be treated as separate 'phrases.' In multi-clause utterances, the
effects of the extra clauses are reduced compared to those of the initial
clause phrases, to the point that each non-initial clause counts as one
'phrase.' Due perhaps to physiological limitations, or to limited 'look-
ahead' by the speaker, the anticipation effect of increased initial peaks
appeared to 'saturate' at a level of about 188 Hz (for JA), with the
addition of a sixth 'phrase' having little added effect on the high initial
peak.

One other factor that must be included in the anticipation model is that
of consonant voicing. Virtually all the initial accented words in set G
started with a vowel or voiced consonant. Unvoiced consonants had higher Fo peaks in ASs, as reflected in #28-29, where the initial words ("quick," "shrill") had Fo peaks +19 Hz greater than predicted by the model. This 'unvoiced boost' should be added to the model with the caveat that Fo not go much higher than the 188 Hz apparent 'saturation' level (e.g., the initial word "small" (#26) had a 184 peak, which follows the model guidelines without the unvoiced effect). Also, when an initial unvoiced accented word had an US following the accented one, Fo overshot into that syllable, and the effect of raised Fo due to the lack of voicing appeared muted (e.g., "foxes" in #12 had the same initial peak as the voiced words there). Finally, when the initial accented word was not the subject, but an introductory phrase (e.g., "In the Arctic, . . ." (#30) or "Thus, . . ."). (#31)), the anticipation effects followed the model, counting the ensuing subject as a separate phrase.

7.2.1.2) 'Set-the-Level' Interpretation

Since the values of Fo peaks in an utterance vary with such factors as its length, as well as the age and sex of the speaker (and amount of effort the speaker uses), the absolute values of the peaks cannot be used to determine how much accent is present on a particular word, nor how important it is in the sentence. However, the relative relationship among Fo peaks (as well as relative amounts of Fo rises/jumps) in the same utterance, or among similar-length utterances by the same speaker in one speaking session, can be used as an indicator of Fo accent. In fact, the relative difference in Fo heights of the first two peaks in a sentence was the best way to judge
the importance of the first AS, since the absolute Fo height (and amount of Fo rise) of the first AS depended on sentence length to a large extent.

One way to view the 'anticipation' effect is in terms of the first AS 'setting the level' of Fo for ensuing accents. In most utterances, the largest Fo rise and peak occurred on this first AS (called the 'head'), and ensuing peaks and rises were progressively smaller. When sentences were long, the first accent had to 'set the Fo level' high enough to allow the ensuing Fo accents 'room' to implement the rise and fall of each remaining SC (Fig. 131).

Similarly, utterances with several words of varying importance had their Fo peaks and rises displaced from the 'normal' case. When an AS in the middle of the utterance occurred in the most important word of the sentence, its Fo peak was sometimes larger than the head peak. While the head peak can be considered to 'set the level' for ensuing peaks in that it establishes a base Fo against which to judge those remaining peaks, large Fo peaks in the middle of an utterance also seem to set the level for immediately ensuing peaks, in that those following peaks vary proportionately with the height of the large preceding peak (higher following higher, and vice versa).

Atkinson claims that the initial Fo peak "sets the level of the entire contour," i.e., a higher (or lower) Fo value at the start correlates with "the entire contour generally [remaining] above [or below] normal" (1973:70).
He thinks this effect "involves random shifts in the average Fo level" in which "the relative Fo within the contour remains relatively stable" (35); however, the findings here support a conditioning upon utterance length.

7.2.2) Proximity Phenomena

7.2.2.1) Separation

Since Fo accent, like Fo movement in general, is relative, the amount of one accent must be compared against others in the same utterance to decide which words receive the largest accents. The size of an accent is usually assumed to be proportional to the degree of importance the speaker attaches to the accented word (e.g., Bolinger: "relative height for relative importance among the accents" (1964b:26)), but phonetic factors have an effect.

Most utterances had several PA syllables competing for accent. In addition to other factors affecting Fo, the degree of time or syllable 'separation' between two ASs affected the amount of accent each received, viz., the accent a syllable got decreased as the number of USs before it and after it was increased, ceteris paribus. Bierwisch noted this type of effect, where "stressed vowels . . . receive pitch values that depend upon the distance that separates them from the most strongly stressed vowel of the unit" (Collier, 1972:169). Similarly, van Katwijk noted a "suction effect" in which a "preceding rising syllable withdraws stress marks from a following falling syllable" (1969:71).
Two ASs, both competing for accent, enter into a 'trading relationship' if they are not sufficiently 'separated' from each other by a number of USs. If two or more USs occurred both before and after an AS, it was considered 'well-separated' from other accents, and was not much affected by the trade-off; whereas 2 ASs closer to each other lost some Fo accent each, in inverse proportion to the number of surrounding USs.

'Weak' content words (such as the verb "study"), which received no accent when immediately preceded by an AS (such as "not" in Table 3, or a dummy, modal, or negative in Table 2), received primary accent in most cases when one US (such as an aux) intervened, and in virtually all cases when 2 or more intervened between ASs.

The increase in surrounding accents which occurred when an unaccented aux was added to a sentence was not simply confined to an extra Fo rise on an ensuing AS, aided by the lower Fo resulting from the Fo fall on the added US, but also resulted in increased accent preceding the insertion. The backward accent-enhancing effect of USs was mostly limited to one syllable, i.e., the presence of more than one US after an AS appeared to have little effect on its accent. Similarly, the forward effect decreased in amount per extra US: an ensuing Fo accent was enhanced primarily by the first and second USs prior to it, and only marginally by more USs; this occurred because the Fo fall-off during USs 'bottoms-out' after 2 or 3 syllables, with little additional drop thereafter.
Only in utterances with equally-spaced and equally-important ASs did the sequence of successive Fo peaks and rises follow a strictly monotonic, linear decrease. When the spacing of ASs varied, the monotonic decrease of Fo peaks was interrupted; a direct succession of two ASs, for example, had a smaller peak than normal on the first accent and a larger one on the second, and both Fo rises were smaller than normal (since Fo was not allowed to fall freely before the second Fo rise). Conversely, an AS well separated from others by USs had a larger Fo rise than normal.

Back-to-back Fo rises necessarily push Fo higher than when an US intervenes. In back-to-back accents, the rise accent was found almost entirely in the nucleus rise, with very little prior Fo jump (indeed, Fo often fell several Hz between the syllabic nuclei, in order to create the 'Fo room' for the imminent Fo rise); whereas in cases where an US intervened, about 1/3 of the accent took place in the prior jump.

Back-to-back accents are similar to 'double rises' (Figs. 29ac & 30b), cases where Fo rose continuously on two consecutive syllables, thus creating a SC starting with two 'accented' syllables. Classifying this Fo pattern as contained in one SC, rather than two (with each AS starting its own SC), is somewhat arbitrary. However, the cases described as successive ASs starting their own SCs have been cases where sizable Fo rises (greater than 10 Hz) occurred on each of the syllables, and further, where there has been some discontinuity in the Fo pattern between the two rises. In cases like "Joe then . . ." or "Joe might . . ." (Figs. 41c & 18d-e), Fo rose in
the first syllable, then levelled off before resuming a rise on the next syllable; furthermore, many of these cases exhibited Fo drops between nuclei.

7.2.2.2) Accent Alternation

English has often been called 'stressed-timed,' in that stressed syllables are supposedly spaced at equal durational intervals. Most actual acoustic studies have disputed this; however, there is a tendency in English for ASs to be longer than USs. Related phenomena, sometimes called "rhythm rules," have been observed (Lightfoot, 1970:54; Vanderslice, 1968:93; 1972:1055). Bolinger notes that "the commonest supporting cue" for an accent "is flanking by unaccentable syllables" (1958a:131; 1961a:311), that "accented and unaccented syllables tend to alternate with each other" (1965:140, 153), and that English has "a general tendency . . . to have prominent syllables flanked by subdued ones" (1962:130), since "more than one unaccented syllable between accented ones . . . gives an extra margin of safety" (133), so that an AS will not be "misinterpreted" as unaccented (130).

One Fo phenomenon related to separation is a form of 'accent shift,' in which the AS of an accented word will sometimes shift around within the word in response to the pressure of other nearby ASs, as in "the problem is complex" - "a complex problem" (Bolinger, 1961b:115; 1965:141; Vanderslice & Ladefoged, 1971:12, 19). Bolinger notes that English speakers have "a tendency to push" "two marked peaks of pitch" as far from each other as possible (158; 1961b:114; 1964b:23). Similarly, Pilch notes a type of Fo
"alternation," in which the medial element of a 3 word phrase loses its accent (1970:95). Baker notes that a normally unaccented aux can receive accent if adjacent to other unaccented function words (1971:175), especially if no AS occurs after it in the utterance (178).

7.2.2.3) Competition

When a sentence has several ASs, each is likely to receive less accent than if fewer were present; as Takefuta et al note: American English has "a definite tendency toward smaller but more peaks and valleys in the melody curves of longer sentences" (1972:1039). In examining sequential properties of Dutch ASs and USs, van Katwijk & 't Hart found that "the occurrence of an [AS] has an inhibitive effect on the occurrence of a following" AS, which "lasts for about 3" USs (1969:83, 86). This 'competition' Fo effect occurs in all utterances with two or more accented syllables, unlike the separation phenomenon, which only affects Fo patterns when two ASs are proximate. One correlate of the competition effect is that Fo was lower at the end of a longer utterance, just as it was higher at the start.

7.2.3) Summary

The local accent patterns superimposed upon the global carrier were phonetically modified by 3 effects: anticipation, separation, and competition. In anticipation, the speaker set the level of Fo higher at the start to allow additional 'room' for the additional Fo variations present in longer utterances. The initial Fo peak was proportional to the number
of 'phrases' in the sentence, where 'phrase' was defined as a simple syntactic unit of the form: noun, verb, adjective, PP, and clause. However, in long utterances, the initial peak went no higher than a certain 'saturation' level.

In separation, an AS received its biggest accent when 'well-separated' from other ASs by 2 or more USs. When 2 ASs occurred with 0 or 1 US intervening, each lost accent. Back-to-back ASs had decreased accents, and little of the accent took place in prior jumps. In competition, the more syllables receiving accent in a sentence of a given length, the less accent each gets; e.g., when a sentence in context had some old words, the new words got bigger accents than without the context.

7.3) Phonemic Phenomena

7.3.1) Consonant Voicing Effects

This study has concentrated primarily on Fo patterns during the syllabic nuclei of each utterance, ignoring Fo variations in the lower energy portions of voiced consonants. However, in the case of ASs with initial consonants, the voicing characteristic of the first consonant had the significant effect on the ensuing vowel's Fo of altering the initial and peak values: raising them for unvoiced consonants and lowering them for voiced ones. Fo typically rose after a voiced consonant to a lower peak value, whereas it fell from a higher peak value after an unvoiced consonant (Fig. 5).

An initial unvoiced consonant does not guarantee a falling Fo slope.
Almost invariably, Fo rose more following a voiced consonant than an unvoiced one, ceteris paribus, but two situations allowed Fo rises after unvoiced consonants: initial position and heavy accent. Since Fo usually does not have a fall on the initial AS of a P-unit, Fo normally rose there even after an unvoiced consonant (as in "Some boys" (Figs. 30-32)). Heavy Fo accent, as occurred in words high on the accent list (e.g., sentential adverbs), often led to an Fo rise on the vowel after a large prior jump during the unvoiced consonant. The unvoiced adverbs "simply" and "occasionally" (Fig. 46) illustrate this well. Initial falling Fo only signals an initial unvoiced consonant if Fo has had a prior upstep; USs had falling Fo whether the initial consonant is voiced or not.

In analyzing falling contours after high Fo peaks (over 140 Hz) in the utterances of set D for JA, some parameters of the fall were found to depend on phonemics. After a typical peak in the range of 145 - 200 Hz, Fo averaged a descent across a word boundary of about 43% of the Fo distance to the BOR. These descents were about 20-25 Hz. However, when the descents occurred within a word (e.g., "simply," "even"), the phonemics of the transition period came into play. When an unvoiced consonant occurred between the syllabic nuclei (as in "simply"), Fo typically dropped 56%, whereas when the transition was all voiced (as in "even"), Fo only dropped 28% of the way to the BOR. Such phonemic effects did not seem to occur between words, only within them.
In Table 151, a set of 9 sentences were recorded by 3 speakers
("This car will be X on the road"); the verb X was varied in phonemics
and lexical stress location. Averaged across the speakers, the peaks on
"This," "car," X, and "road" ranged over 14 Hz (135-150), 15 Hz (129-144),
11 Hz (122-133), and 12 Hz (100-112), respectively. Following the carrier,
each peak averaged less than the one before. The descents on "car" ranged
over 16 Hz (-35 to -19) compared to the small fall-offs of -13 to -4 on
"will be." When X began with an US (e.g., "identified," "demolished"),
the US had only a -2 further fall-off. The rise accents on X ranged over
13 Hz (+18 to +31) compared to 6 Hz (+8 to +14) for "road." Fo in "on the"
ranged from 89 to 100 Hz (i.e., stayed in the BOR).

On X, the peak averaged only +3 higher after an unvoiced than voiced
consonant, but there were large differences in how the AS of X got accent.
Specifically, with voiced X, Fo jumped +25 and rose only +1. Other phonemic
differences appeared in the manner and size of the descent of the AS of X:
when the AS ended X, it got a -32 fall and only -4 further drop to the
next syllable if X ended in a voiced phone ("cleaned," "destroyed"), but
only -12 fall and -11 ensuing drop if unvoiced ("built"). When an US
followed the AS in X, the descent was less (-14 vs. -38); when the AS
ended in a voiced phone (e.g., "demolished"), the descent had -6 fall
during the nucleus and -5 drop after; when unvoiced ("tested"), it had
-5 fall and -20 drop. Thus, the rise accents were greater for unvoiced
starts and had more prior jump than rise; similarly, ending the AS with
an unvoiced phone led to less fall and more drop. Among the ASs having a voiced end, those ending the word had much greater descents (−36 vs. −11).

7.3.2) Discussion

In monosyllabic accented words, Lehiste & Peterson report that "higher fundamental frequencies occur after a voiceless consonant and considerably lower fundamental frequencies occur after a voiced consonant" (1961:420), and that "when the initial consonant was voiced, the [F0] peak occurred in the middle of the [syllabic] nucleus of the target word, with a rather smooth glide of the fundamental (usually upward but often down on voiced plosives) during the initial voiced consonant. If the consonant was voiceless, and particularly when . . . a voiceless fricative, the peak occurred immediately at the onset of voicing, and the fundamental on the syllable nucleus thereafter decreased" (Peterson & Lehiste, 1960:698), but that "the final consonants have no such regular influence on the preceding syllable nuclei" (Lehiste & Peterson, 1961:420; Lea, 1973:36). Similarly, Mattingly notes that "if voicing is interrupted by voiceless sounds and then resumed, . . . the fundamental is slightly higher than before voicing was interrupted" (1968:171), about "a semitone higher" (175).

In a perceptual experiment using "a synthetic VCV utterance," Chistovich found that "an F0 dip of 12 Hz or more" made the labial consonant C "sound like an obstruent, as opposed to a sonorant" (Lea, 1973:41); i.e., the phonemic distinction between /b/ and /m/ could be cued by the depth of
the Fo dip. Similarly, by varying "the pitch curve at voicing onset," Haggar et al found that "a low rising pitch leads to perception of an initial stop consonant as voiced, while a high falling pitch leads to perception as voiceless" (1970:617); thus the phonetic Fo effect is not merely an artifact, but is useful in phonemic perception. Similarly, Fujimura found that Fo variation caused a shift of the voiced-voiceless boundary for stops concerning "the primary cue," viz., "voice onset time" (VOT) (1971:224). Specifically, adding an Fo "inflection" of a linear rise "from 70 Hz to 100 Hz during the initial 150-msec period of voicing" (222) caused a bias towards perception of the stops as voiced. He considers this Fo effect as "a secondary cue" which "casts a deciding vote" when the primary VOT cue is "not clear enough," but is "often easily overridden . . . if the primary cue has a counteracting effect" (224).

In modeling Fo, Rabiner restricts consonant effects to "local perturbations" of the Fo contour (1968:30). However, Löfqvist reports for Swedish that "the influence of the preceding consonant . . . was . . . not confined to the beginning of the vowel but was still present when the Fo peak was located near the end of the vowel," and further that "after voiced consonants the peak Fo of the vowel was about 15 Hz lower than after unvoiced consonants" (1973:60). Similarly, Lea found for English that "initial Fo values in stressed vowels are about 20% higher when the preceding consonant is unvoiced" rather than voiced, and that "peak Fo values . . . are about 10% higher" there (1973:43). He further noted that "synthesized speech is more natural when" these consonant Fo effects are
included (46). Witting notes that voiced stops are accompanied by small Fo fall-rises (or "dips"), when such a stop "is surrounded by vowels" (1962:141). Lea finds that "central Fo values in voiced obstruents are about 13% lower than in sonorants" (1973:43).

7.3.3) Summary

While little difference in the Fo contour was found on USs due to phonemics, ASs exhibited varied patterns due to consonant voicing. When an AS started with an unvoiced consonant, the accent was bigger and consisted of more prior jump and less nucleus rise, than when the AS had a voiced start. Often in unvoiced ASs, there was no rise at all; but when the AS got heavy accent and when the AS was non-final in a word and initial in a syntactic phrase, the AS often di... have a prior jump. When the AS was not the final syllable in a word, there was less descent on the AS when it ended in a voiced than an unvoiced consonant. In contrast, when the AS was word-final, it had more descent when ending in a voiced than unvoiced consonant.

7.4) Variation and Speaker Freedom

7.4.1) Inter-speaker Effects

7.4.1.1) Ranges of Fundamental Frequency

Fo patterns tend to vary among different speakers (Fry, 1970:45). Besides the obvious differences related to vocal tract anatomy among speakers (leading to varying Fo ranges and levels), certain Fo patterns seem to be speaker-dependent (these might be useful in speaker-recognition
routines). Ainsworth speculates that listeners may use Fo to "normalize" among speakers (1974:125; Atkinson, 1973:31, 63). In this study, such factors as how rapidly Fo fell after a peak and whether Fo tended to 'overshoot' an AS appeared to be (at least partially) speaker-dependent.

For the most part, the Fo contours for the 5 speakers of this study exhibited similar patterns for identical sentences. The rises and falls occurred on the same syllables at the same relative times for the 5 speakers. However, there were interspeaker differences in Fo, the most obvious of which concerned the different average Fo levels for the various speakers. Age and sex factors cause much variation here, but even the 5 adult male speakers exhibited significant differences, with speaker JA utilizing a wide 140 Hz band of Fo and DK using a more limited 70 Hz range for the vast majority of their read sentences.

The average peak level for a speaker varied with the sentences spoken: longer sentences were more likely to have higher Fo peaks; but, on the average, JA had peaks about 20 Hz higher than those of KS, and 40 Hz higher than ML, DO, and DK. In one-clause utterances, the Fo ranges (highest and lowest values) used were: JA, 80-190 Hz; KS, 65-170 Hz; ML, 70-145 Hz; DO, 55-135 Hz; DK, 70-140 Hz. The Fo peaks in two-clause utterances ranged 30 Hz higher for JA and DO, but no higher for KS. The BORs showed much less variation across speakers than did the absolute ranges; each speaker's BOR was about 15 Hz in width, and gradually decreased in absolute level throughout the utterance (following the lower declination line). The
center value of the BORs was about 93 Hz, with JA and KS having slightly higher BORs, and ML, DO, and DK having lower ones.

7.4.1.2) Other Differences

Different speakers had different falling rates for Fo in USs. Speaker JA utilized a typical falling rate of -150 Hz/sec after Fo peaks, while KS had a more rapid -400 Hz/sec fall. This resulted in KS's Fo reaching the BOR more rapidly than JA's; it also enabled KS more leeway in using secondary Fo marking for the lesser ASs. Since his Fo normally fell quickly after a peak, a slower Fo fall could call the listener's attention to a syllable more easily than in the same pattern used by JA. JA utilized more Fo rises on the lesser PA syllables than KS. This effect might be called a 'time constant' effect, in that, viewing falling Fo as a roughly exponential shape, different speakers have different inherent time constants of fall.

Perhaps a derivative of, and certainly closely related to, the Fo falling rate of a speaker is the way in which his falling Fo divides into drops between, and falls during, the nuclei of USs. KS, with his faster falling rate, had a larger drop:fall ratio than JA (who split his drops and falls about 50:50).

While the speakers consistently marked most MOs with larger accents than on other words, there was less agreement among the speakers on what constituted a class A modal. All 5 showed accents on certain modals in certain contexts, while consistently avoiding accent on other modals;
however, the list of which modals should be called 'A', due to their being accented, and which should be 'B', due to their lack of accent, was not the same across the 5 speakers. The division given earlier describes the situation for JA's speech, and there were even a few examples in his speech in which A modals lacked accent and B modals got accent. All 5 speakers gave accent rises to "might," and ML and DO generally followed the division given for JA, but KS chose to give unambiguous rise accents only to "might" and "shall" among the modals. Thus, while certain modals receive accents because they represent a speaker's comment on the proposition, a single list of those modals for all speakers does not exist.

Other interspeaker differences included: different tendencies to use Fo CRs, and different orderings for the MOs. Compared to the Fo of JA, KS's had more frequent occurrences of continuation rises, and more accenting for negatives and less for modals.

7.4.1.3) Findings of Other Studies

One inter-speaker difference was that of relative Fo height; Fujisaki & Sudo have found (for Japanese) that "pitch contours of the same type of word accent, when plotted in the logarithmic frequency scale, are essentially similar except for a constant shift specific to each individual" (1971:134). Öhman found similar results for Swedish in that "fo-contours of the same utterance spoken at different over-all pitchlevels ... give essentially parallel curves when plotted on a logarithmic frequency scale" (1967:21).
In comparing the various sources of Fo variation, Levitt & Rabiner found that "intersubject differences greatly exceeded inter-replication differences; inter-replication differences tended to be larger during non-stressed portions . . . than during stressed portions" of speech, and "there were substantial differences just before the [Fo accent] peak, depending on when the subject began voicing" (1971:579), but that "differences between contours during the stressed portions" were not due "to complicated differences in contour shape" (581).

Comparing Fo contours for several speakers, Atkinson found "large individual variations in . . . timing, range of excursion of Fo, and general contour shape," which "may reflect differences in physiological constraints," or could be "'learned' stylistic differences which are perhaps dialectal in origin" (1973:29). Ignoring the type and patterns of variability, he claimed that in Fo, "there is as much variability within a single speaker as among several" of the "same sex" (35, 50). In his view, such variability is caused equally by a DC component ("random shift in the average Fo level") and an AC component ("random variability") (35), and involves "timing, degree of Fo rise or fall and average Fo level" (40). The DC variation is "of little perceptual importance," whereas the AC component is the "'true noise' obscuring the linguistic 'signal'" (72). The DC shift is "a significant cause of intra-speaker variability," with the AC component being "relatively smaller"; "inter-speaker variability" showed "the same tendency," but to a lesser degree (64). Such a DC shift "is approximately a Gaussian random variable" (65); and is independent of the AC component (66).
"Such characteristics as Fo rise, Fo fall, high Fo or low Fo are consistently used by all speakers yet the particular shape of an Fo rise say, or the absolute level of high Fo, vary idiosynratically" (73). Atkinson found that the intra-speaker variation is "relatively independent of time between repetitions," except for "one-after-another repetitions where some type of mimicry may be involved" (57), that "variability is greater in yes-no questions than in statements, particularly with respect to the terminal contour" (58), and that a speaker's Fo range seems to be independent of his average Fo (46). He found that prominent syllables "showed far greater variability than the other syllables" (53), in contrast to the above Levitt & Rabiner results, perhaps because Atkinson's study involved utterances with "emphasis" (54) and was recorded at different times, unlike the other study (55).

Another source of inter-speaker Fo variation is that between children's and adults' speech. Adams notes that children have a "tendency to use a greater number of falling pitch sequences," which are even "used quite often in general [yes/no] questions" (1969:90); he thinks that "similar intonation sequences are used by adults and young children alike in normal neutral speech," but that the children "concentrate on fewer patterns and . . . utilize particularly those which assist in word prominence" (91).

7.4.2) Time Synchronization of Fo Movements

The precise synchronization of linguistic Fo movements and the succession of phones (i.e., the manner in which the accent rises and falls align with
the phonemics of the utterance) appeared to be mostly a matter of speaker freedom and phonemics; however, Fo synchronization may have some phonological basis as well. The alignment phenomenon concerns the synchronization of Fo movements with the durations and amplitudes of the speech sounds of the syllable. Any synthesis-by-rule scheme for generating Fo must know when to implement the Fo variations with respect to the ongoing speech signal. Analyses of the Fo contours have accordingly been on a syllable-by-syllable basis, noting where in the sentence various portions of the SCs were located. Each syllable’s Fo variation has been further broken down into those changes which occur in, and those before, the nucleus of the syllable.

Scrubinizing Fo this closely, however, sometimes leads to overlooking some general Fo trends which cover more than one syllable. The SC encompasses several syllables and enables a more global Fo analysis. The SC pattern of rise on an AS and Fo fall thereafter leaves a certain amount of freedom in the manner in which Fo peaks and starts to fall, however.

Gunter describes several intonation variants for marking accent: (1) "a smooth descent," involving an Fo jump at the start of the AS, with a steady Fo fall thereafter; (2) "humped descent," or "over-shoot," in which the Fo rise on the AS continues into the ensuing US, before Fo starts to fall, and thus the peak "comes in an unaccented syllable directly after the accent"; (3) a rise-fall pattern, in which the Fo peak occurs at the end of the AS (1972:207). A fourth possibility is that the peak occur within the AS, causing the fall to begin within the AS. As Gunter notes:
"All of these variants are clearly manifestations" of the same Fo contour (208), and illustrate speaker freedom.

In this study, the following 3 patterns (in order of decreasing frequency) were observed (Fig. 132):

a) Fo rises to the peak of the SC at the very end of the nucleus of the AS, and Fo in the next nucleus (which is unaccented) starts falling from a level lower than the peak.

b) Fo rises to the SC peak and then falls, both during the accented vowel, with a continued fall in the next US.

c) Fo rises during the AS, but continues upward to a peak during the next nucleus (unaccented), and then Fo falls. Fo overshoots the end of the AS before it falls.

One could consider pattern (a) as the basic, 'unmarked' Fo shape for an AS, and the other two as modifications. Pattern (b) may lend more 'emphasis' to the AS since more Fo movement occurs on it (not only a rise, but a rise+fall); whereas the 'overshoot' of pattern (c) may lend less emphasis since the Fo peak is not attained during the AS.

One reason why 'synchronization' could be tentatively placed under the aegis of speaker dependencies was that one of the speakers (ML) showed a marked tendency toward pattern (c) in his SCs while the other speakers were more limited in their use of it.
7.4.3) Speaker Freedom

7.4.3.1) Variation within a Pattern

In relating the distinctive aspects of intonation and the tolerance range allowed, Lee notes: "there is a pattern aspect and an aspect of variation about the pattern. The pattern itself is not always rigid, . . . some features are pattern features while others are not . . . . The limits of variation are wide: much can be done without obliterating the pattern"; he claims that, in conveying two specific Fo patterns, "the extent of fall and rise . . . can be varied," "strong stresses" not related to the pattern "can vary in number and be variously placed" (1956:354). Gaitenby allows that "aside from duration, considerable prosodic variation (elasticity within and across syllables) is permissible . . . Mild prosodic and phonetic deviations from the norm . . . may be heard as dialects -- to which most listeners can adjust themselves, as long as the variations are regular" (1975:138).

Referring to a fall-rise contour, Jassem claims that "the size of the [Fo fall] interval . . . is probably largely dependent on momentary or permanent neuro-physiological states," rather than being "related to any semantic (or 'attitudinal') differences" (1972:249); he also notes that many of the differences before the end of an Fo contour "are apparently in free variation" (251). Similarly, Collier notes that much of the "variation within the hat pattern is free" (1972:83), and that his Fo patterns allow for several "free variant[s] of the same basic type" (104); he also gives probability statistics illustrating the various sequences of Fo patterns in
Dutch utterances, without explaining why the successions are not deterministic (141, 144, 147) (e.g., "the transition probabilities between pitch movements appear to be very variable" (149)). Thus one might conclude that the speaker is free to select among these patterns; however, Collier claims that "intonation is . . . more than a statistically determined generation process" (150).

A number of authors have noticed wide ranges of Fo in their data for various experiments (Lehiste & Peterson, 1961:424; Takefuta et al, 1972:1039; Maeda, 1974:203; Hultzén, 1964:92). Studies seeking distinctive (even phonemic) levels of Fo have failed (Bolinger, 1951:206, 209). Lehiste & Peterson note that "a linguistically significant intonation level may have a wide range of phonetic manifestations . . . . The variations in Fo . . . may be greater than the variations associated with changes in segmental quality; the differences can only be established, when a sufficient number of utterances are compared" (1961:425).

Bresnan has noted a "phenomenon of stress optionality" (1972:337), by which the speaker has freedom to choose among a number of alternative words to which main stress may be given. Pierce calls this behavior "free fluctuation" (1966:56) or "free variation," and notes that not all Fo variation need be "conditioned," and that "there is great variation within a given language with no change in meaning" (57; Gårding & Abramson, 1965:79). This 'optionality' is present in all utterances in which more than one word is eligible for accent, i.e., where more than one content word is new or
unpredictable. In such cases, the speaker is free not only to place 'main stress' on any of them, but also to vary the amount of accent each AS receives.

7.4.3.2) Examples

Whereas the average Fo peaks and rises on the accented verb "study" varied considerably (for JA peaks ranged over 27 Hz, and the average rises ranged from +10 to +29), the Fo behavior on "study" after the prior jump varied little phonologically. The slopes of Fo during "study" were virtually always falling from an Fo high at the start, due to the initial unvoiced consonant. The slopes ranged from 0 to -450 Hz/sec, and compensated each other to a certain extent: usually Fo fell more rapidly on the first syllable than the second, but when the second fell rapidly, the first fell slowly. There was a tendency for the Fo slope in "stud-" to reflect that in the preceding syllable, in that the Fo slope was slight when the preceding Fo slope (in the aux or subject) was also slight, and that it was steeply falling when the preceding syllable had a steep rise in Fo. When an AS ended the aux sequence with an Fo rise, the slope in "stud-" averaged -230 Hz/sec, whereas with other aux sequences (ending in an US), the average "stud-" slope was only -165 Hz/sec.

A statistical analysis of the utterances in set A for speaker KS was given in 4.5, and exhibited amounts of intra-speaker variation for different words in a simple sentence. A similar analysis for the sentence "Bears and gulls live in the Arctic" is given below for JA. This sentence was recorded
22 times at random locations in set G, and, unlike the sentence in 4.5, had P-units in its Fo pattern.

Fig. 133 displays the distribution of Fo peaks in "Bears," "live," and "Arc-": they averaged 172, 131, and 119, with standard deviations (SDs) of 8.5, and 7, respectively (note the carrier effect). Fig. 134 shows the spread of the rise accents on "live" and "Arc-", and of the CR at the end of "gulls": they averaged +15, +5, and +8, with SDs of 4 each, respectively. Thus, there was less variance among the rise accents than among the peak values.

Fig. 135 illustrates the range of descents on "and," "gulls," "in," "the," and "Arc-"; the descents averaged -14, -27, 0, -10, and -28, with SDs of 8, 11, 3, 2, and 6, respectively. In addition, the prior descent of "gulls" was -18 (SD of 9). Thus, the descents on the USs ("and," "in," "the") averaged -28, and the prior descent on "gulls" was 9 smaller than the fall accent from its peak. The USs inside each P-unit ("Bears and gulls," "live in the Arctic") had slow fall-off rates compared to the ASs ending the P-units.

"Live" got +10 more rise accent than "Arc-" because "live" started the second P-unit; "gulls" and "Arc-" relied on their bigger descents to mark accent. "Gulls" exhibited considerable variance in these utterances; its prior descent and fall accent had large 9 and 11 SDs. In contrast, the rise accents were more consistent with SDs of 4. These results indicate typical
variations in the Fo patterns of this study, and exemplify the difficulty of isolating the many Fo effects present in each contour.

7.4.3.3) Dialects

Another source of Fo variation involves dialectal differences within a language such as English. This thesis concerns Fo in General American English, but English has other dialects, such as Australian and British (the latter sometimes called Received Pronunciation (RP)). Fo in the Australian dialect has been described by Adams (1969:81) and Burgess (1973:314), while RP has been observed by many authors (Armstrong & Ward, 1926; Kingdon, 1958; Schubiger, 1958; Halliday, 1967; Crystal, 1969b). Some differences in intonation between American and British English can be striking ("there are many patterns used by both dialects and many that are not shared" (Peck, 1969:107; Trager & Smith, 1951:43)); e.g., Bloomfield notes that "the Englishman's rising pitch . . . in some statements makes them sound . . . like a yes/no question" to "American ears" (Adams, 1969:128). Regarding the syntactic use of Fo, Jassem notes: "Some Americans think that Englishmen do less than they might to make understanding easy" (1964:95). Kingdon notes that, "to most speakers of other dialects," RP "seems 'clipped' . . . because the kinetic tones [i.e., Fo variations on the nuclear syllable] are definite and of comparatively short duration" (1958:261).

Chatman notes that "American English" has "considerably less intermediate jumping upwards . . . than in British English," that "American English
almost always has a level or rising onset" of Fo, while "British intonation" has a "tendency to start at a high pitch" (1966:33), and that "American English tends to use the final rise in fewer situations than British English. A final rise often occurs with statements in British English to show some sort of tempering of the assertion, ... to make it more polite, or more hesitant, more apologetic," etc. (35). "Similarly, the 'polite' use of rising intonation with interrogative word questions is very rare in American English but quite common in British" (37), and "the rise-fall-rise contour, usually suggestive of strong implication in British speech" is "uncommon in the English of Americans" (38). Mattingly says of the Fo fall-off in the global carrier that its "slope seems to be a dialectal feature: it is very small for General American and rather large for Southern British English" (1968:170).

While the intonational differences between languages can be extensive, Bolinger has postulated a number of possible "language universals," such as: the carrier falling Fo pattern (1964a:835), "lexical stress" being "conveyed by a rise in pitch" (834), and a high, non-falling Fo for questions (836). Cohen & 't Hart found experimental evidence (by presenting, for perceptual judgments, 600 Hz low-pass filtered speech of 4 different languages) that some languages could be distinguished "on the basis of intonational cues" (1970:81). In comparing English Fo to that of other languages, Kingdon found that Spanish tends to put Fo accent on some old information words (1958:264), and that "the intonation of German is very similar to that of English," with the exception of "a stronger tendency towards early stress
... so that the nucleus frequently falls early and seems to be more prominent than it does in English" (267).

Brend claims dialectal intonation differences between American men and women (1972:866). She thinks that, unlike men, women use more of: "more polite' incomplete longer upstep[s]" in Fo, and "high-low down-glides" indicating "'unexpectedness' and 'surprise'" (867). "Men consistently avoid certain intonation levels or patterns," e.g., "the highest level of pitch that women use": "men avoid final patterns which do not terminate at the lowest level of pitch, and use a final, short upstep only for special effects, for incomplete sequence, and for certain interrogative sentences": they "avoid the one-syllable long pitch glides, and ... reverse glides on one syllable ... in general communication situations" (868). Gaitenby found that the female speaker in her experiments (who had an "atypically low vocal register for a female") nonetheless "produces pitch excursions that are more extreme and generally higher" than her male speakers (1975:143).

A final 'dialectal' source of Fo variation occurs in the manner and context of the speech source. Crystal has noted varied prosodics in "loud reading" vs. "conversational" speech (1969a:382). Harris & Umeda found that "temporal factors" were different in "isolated words or carrier phrases" than in "a connected-text" (1974:1016), and tentatively suggested that "in carrier phrases the speaker does not have to convey the content of the message to the listener, and so prosody becomes more mechanical" (1018).
However, any read speech would be susceptible to the problem of lack of speaker motivation, not just isolated sentences; connected text may make the task easier for the speaker, but what really matters is how well he carries out the task of uttering the read speech properly.

7.4.3.4) Emotional Connotations

Van Katwijk theorizes "a model of Dutch pitch contours" (similar to that of Isačenko & Schädlich (1970)), characterized by two modes, two pitch levels, and pitch changes between the levels whose temporal locations determine the stress information" (1970b:89). These two modes of Fo are distinguished in that mode 1 uses upward Fo obtrusions to effect stress, while mode 2 uses downward Fo obtrusions (1970a:86; 1970b:92). The "mode has some perceptual substance," but "it would be difficult to designate an objective correlate for it" (93). For English, Lea notes that "decreases in Fo are sometimes the mark of stressed syllables in non-neutral semantically-marked expressions such as for some emotions and for special emphasis" (1973:67).

Bolinger refers to "the difference between an accent that jumps up from the reference line, and one that jumps down" as a "significant emotional overtone . . . in accent," in which "the upward jump is unrestrained" (1964b:24), whereas "the downward obtrusion" is used "in situations where gentleness or restraint is called for" (1958a:135), or "to express comfort, reassurance, doubt," or "reservation" (1964b:25). He also refers to these downward jumps as "inverse accents" or "reverse accents," which "are apt to be taken as conveying formalized, hence insincere, emotion" (1970:124).
7.4.4) Speaking Rate

One parameter with considerable effect on the Fo contour that is not directly linguistically or phonetically conditioned is that of the rate of speech (which Lea & Kloker suggest be defined in terms of "the usual inter-stress interval that does not span a major syntactic boundary" (1975:44)). A faster speaking rate forces the linguistic Fo movements to be performed in less time, and leads to less Fo variation; whereas a slower rate allows sufficient time for all linguistic Fo movements, including some optional patterns not seen at faster rates (such a slow rate of speech has been called "careful speech" (Trager & Smith, 1951:72)). "In rapid speech," some "prominences may all but disappear" (Bolinger, 1965:161). "The more rapid the speech, the fewer potential rhetorical accents are actually given sentence stress and rhythmic accent" (Lightfoot, 1970:56). Koshikawa & Sugimoto claim that the slopes of Fo changes "depend appreciably on conditions of the voice effort and of the speed of the utterance" (1962:2).

Lee notes that "there are . . . more kinetic [Fo] tones in slow emphatic speech, which is analysable into a greater number of movements," than in normal speech (1956:370; Allerton & Cruttenden, 1974:15). Stockwell claims that "a slowing down of the sentence introduces optional pauses and thereby . . . more intonation contours than appear in the corresponding faster version. Optional phrasing of this sort . . . is a highly regular phenomenon. It operates on the general principle that pauses must be introduced between higher ranking constituents before . . . lower ranking ones" (1971:33).
To examine these claims, 15 sentences in set H were recorded at 4 different speaking rates. Since the speaker (JA) normally spoke at a relatively slow rate, he was asked to speak at a faster rate. This was repeated 2 times; hence each sentence was read at a normal rate (cases #1 in Tables 89, 152-161, & 127), and at 3 successively faster rates (#2-4). Considering the speaking rate in #1 as 1.00, the average rates in #2-4 were 1.19, 1.25, and 1.51 (e.g., #4 was read at a rate 1.51 times the rate in #1).

The expected decreases in accent and Fo level did not occur; instead, Fo increased in #2, but decreased with further increases in rate. Specifically, in Tune A utterances, the accent peaks averaged 143, 151, 147, and 144 Hz, and the rise accents averaged +18, +20, +17, and +19 in #1-4, respectively. Similarly, in Tune B utterances, the average peaks were 177, 191, 186, and 176, respectively, in #1-4.

Apparently, when first asked to increase speaking rate, the speaker used more rapid speech, but 'compensated' by increasing Fo variation. Only when the rate was increased further (e.g., in #4) did this compensating effect diminish. Yet #1 & 4 had similar accent patterns, levels, and ranges. Since the faster speech utilized essentially the same amount of variation, it was the Fo rate or slope that changed. Rather than reduce Fo variation as speaking rate was increased, the speaker increased slope to preserve the same amount of variation in less time. This finding is important with respect to the choice of amounts of accent, rather than slopes, as the
parameters for analyzing the Fo contour. The algorithm in Chapter 8 describes the contour in terms of Fo changes; to synthesize different rates of speech then, the durations of the words are simply adjusted.

7.4.5) Summary

The Fo contours in this study exhibited both inter- and intra-speaker variations. The 5 adult male speakers had varying inherent ranges and levels of Fo. They also differed in their falling-rates, their use of 'overshoot' in ASs, and their tendency to give more accent to various MOs. Recording the same sentence 22 times, JA exhibited typical variations from the standard P-unit patterns in that peak values and amounts of rise accent and descent varied randomly within a certain range with each repetition. However, the crucial differences were maintained even with the variation. The rise accents were clearly bigger on the ASs, and the descents greater at the end than in the middle of a P-unit. In speaking at different rates, the Fo levels and accents were changed less than the slopes were. In starting a SC, the Fo trajectory always initiated the rise on an AS, but varied as to its final location: it could peak on the AS and fall, or peak on the ensuing US.

7.5) Economy in Fundamental Frequency Movements

One general principle of Fo implementation is that of economy of effort. As in many other human activities, with speech the speaker seeks to optimize his communicative ability with the least amount of effort. Since speech communicates well, even in noisy environments, it must have inherent
redundancies so as to allow certain aspects of the speech signal to be corrupted, without the listener misinterpreting the message. The linguistic information conveyed by the variations in Fo can be transferred by other methods; monotone utterances can be understood. Thus there is no fixed amount of information that must be carried by the Fo variations. The emotional content of the speech, which is often transmitted in the Fo, may be conveyed by the speaker's facial expression, the context of what he has said, and/or other prosodic variations. The syntactic and semantic information often conveyed by Fo movements may, on occasion, be omitted if the context permits, or it may be conveyed by other prosodics. Often, when one speaks rapidly, certain speech cues are slurred or deleted; Fo variations are likely to be among these lost cues. On the other hand, in noisy environments, one frequently has to articulate precisely and slowly in order to make oneself understood; in these cases, it is likely that all of the 'normal' Fo variations are retained, and perhaps even exaggerated.

The main point is that, while certain Fo variations are sufficient to convey certain linguistic information, they are usually not necessary. Seeking the least amount of 'effort' necessary to convey his message, the speaker implements enough of the various speech cues, including those of Fo movements, to make himself understood. This is one of the main reasons why the basis of this study has been the readings of isolated sentences, carefully controlled as to syntax, semantics, and phonetics. By presenting the sentence without supporting paragraphs or questions, it was hoped to allow as much of the possible Fo variations to exhibit themselves, so that
they could be correlated with the controlled factors of the sentence. In more contextual speech and in spontaneous speech, many other factors are present which take some of the linguistic burden from Fo.

While 'effort' is difficult to define for Fo production, it is likely that raising Fo and keeping it high require more energy by the speaker (see 2.5.1); hence the speaker seeks to minimize high Fo, with the constraint that the message be conveyed. If in uttering a sentence, the speaker finds himself misunderstood, he often repeats himself, but places greater Fo variation on those portions of the sentence that were misunderstood.

The 'economy of effort' principle exhibits itself in several ways in the implementation of Fo. As noted above, longer sentences start with higher Fo peak; this can be viewed alternatively as shorter sentences having lower Fo peaks, since, with a lesser number of ASs to receive accent, Fo need not go as high as it must when preparing for many ensuing accents. Thus 'anticipation' can be seen as a converse of effort economy; since raising Fo higher requires more effort, the speaker refrains from doing so, unless it is required by the length of the sentence. The gradual decrease in the height of successive Fo peaks is likely an economical occurrence, since it requires more 'effort' to sustain Fo at a high level than to let it gradually decrease.

The P-unit represents a trade-off in economy: 2 ASs are contained
within one Fo obtrusion, but extra effort is expended in retaining Fo at a high level during the medial section of the P-unit. Minimization of effort may partially explain the tendency in English for simple non-coordinated NPs to have the longer of 2 words second rather than first; e.g., in "salt and pepper," Fo need only remain high for one US, rather than 2 in "pepper and salt." The sharp rises and falls in P-units often exhibited patterns suggestive of the use of accelerator and decelerator muscles; rather than exhibit a smooth rise or fall occupying the entire AS, the sharp rise or fall often came in the middle of the syllable, with Fo relatively level both before and after. It was as if an Fo muscle command were given to suddenly 'switch' levels, e.g., from high to low.
8) **An Algorithm for Fo Generation-by-rule:**

This chapter is an attempt to put into an organized framework those phenomena observed in analyzing the Fo contours of this thesis. Satisfying one immediate objective of this work, a program was written in BCPL to generate Fo contours for a synthesis-by-rule scheme. In this algorithm, the observed Fo effects have been divided into two main groups: High level and Low level.

**High level** Fo effects in an utterance are those related to the semantic meaning of a sentence, and the syntactic framework in which those ideas are conveyed. These are the Fo phenomena which are directly related to the linguistic content of the sentence to be spoken, and for which the speaker has most direct control. These effects are not concerned with such details as phonemics, lexical word stress, or the number of syllables in a word, but rather with semantic categories of words, syntactic word classes, and surface tree structures.

**Low level** Fo effects are those involved in modification of the Fo contour specified by the abstract, underlying Fo gestures which are the output of the High Level System. Phonemics, lexical stress, and the number of syllables have direct effects in the actual implementation of an Fo contour. Such Fo phenomena are those for which the speaker has little direct control.

These 2 levels can be considered as separate systems in cascade, or
2 'black boxes,' which, when cascaded, form the Fo-by-rule generating system (see Fig. 136). The High Level System (HLS) accepts syntactic and semantic information as input, and produces a set of 'prosodic indicators' (PIs) as output. These PIs are supposed to be representative of the abstract Fo gesture commands sent neurologically to the Fo-implementing muscles (e.g., the cricothyroid muscle). (No physiological experiments have been performed, so this interpretation is without firm foundation.) The Low Level System (LLS) then accepts these PIs, as well as lexical and phonetic information, and produces a form of Fo contour as output; the contour output description involves Fo levels and amounts of Fo change per syllable. One (perhaps over-simplified) way of viewing the 2 systems of Fo generation is that of interpreting the HLS as a Psychological system (converting the mental image of a sentence into basic Fo gestures) and the LLS as a Physiological system (converting the abstract Fo commands into actual Fo movements obeying physical constraints).

8.1) The High Level System (HLS)

The HLS accepts semantic and syntactic information about a sentence as input, and yields a set of PIs as output. Actually, the only semantic input needed is a specification of which words the speaker considers important to the message and least predictable by the listener, and a quantifiable measure of each word's importance. Similarly, the only syntactic information needed concerns where to place breaks in the sentence, i.e., which word boundaries in the sentence are most important to resolve any ambiguities and to facilitate speech processing by the listener. Unfortunately,
such information is not easily obtainable from the written sentence. To formulate an algorithm, one must be more precise, and deal with information readily discerned from an input sentence. Among the required linguistic inputs are the following:

a) Syntax: what form-class each word in the sentence belongs to (noun, verb, adjective, adverb, article, pronoun, preposition, conjunction, quantifier, contraction) and also some more specific subdivisions (verbs: finite verbs, aux's, class A and B modals; adverbs: sentential, quantifying, negative; pronouns: personal, reflexive, relative, interrogative); how individual word-units in the sentence combine to form small syntactic units (NP, PP, VP, AdjP, and AdvP), and how these units form larger syntactic units (i.e., the surface structure tree); whether an offset clause is embedded or matrix, independent or dependent; whether an offset phrase is a modifying phrase, an appositive, or a vocative; punctuation (commas, dashes, semi-colons, quotes, parentheses, exclamation points); if the sentence is a question, whether it is a full yes/no or Wh-question, or whether it merely ends in a tag question (and, if a Wh-question, whether it ends in an 'example'; if a yes/no question, whether it is a 'true' yes/no question, or one offering 'alternatives'); whether a word-pair functions as a compound.

b) Semantics: whether a word or phrase is an anaphoric occurrence or a lexical repetition, and if so, how often and how recently it has been mentioned, and whether it has features in common with other previously-
mentioned words; whether a syntactic transformation has been performed upon the deep structure, and if so, which one (i.e., passive, preposing, cleft, dummy-insertion, there-insertion, pseudo-cleft, dislocation, topicalization, extraposition, ellipsis); whether a part of the sentence is selected for contrast (and if so, which part); whether a word is 'unnecessarily' repeated (i.e., it could be pronominalized or deleted without a change in meaning).

Most of the syntactic information can be obtained from a good lexicon and parser; which (if any) syntactic transformation has been performed upon the sentence should also be obtainable with a parser. CS would likely be specifically marked in the input sentence (e.g., as underlining or italics). Lexical repetition can be found through the use of a buffer, keeping the most recently used words for comparison with each new word in the input. However, anaphoric relationships are difficult to ascertain; determining whether a word has some semantic features in common with another is a current problem in linguistics. Similarly, determining whether all possible pronominalization and deletion have occurred in a sentence and whether a word-pair operates as a compound are difficult to decide. This algorithm utilizes such information as input nonetheless, because definite Fo effects have been related to these phenomena.

The output from the HLS is in the form of a parameter set (the PIs):

a) *accent*: an integer for each word specifying how big its accent should be (the higher the number, the more accent); this number is simply
a relative gauge of accent, not an Fo change in Hz.

b) 'break': an integer for each word, specifying whether it should begin a P-unit with an Fo rise (a positive number), end a P-unit with an Fo fall (a negative number), or neither (0); numbers further from 0 indicate bigger Fo breaks.

c) 'CR' (continuation rise): an integer and a label for each word specifying how big a CR the word should end with, and whether it should be a fall+rise CR or a monotonic CR.

d) 'level': an integer for each word specifying what Fo level it should assume; this only applies to NPs not containing conjunctions, so all other words get 'level' numbers of 0; a value of +1 signifies 'hold the Fo level' and a value of -1 notes 'drop the Fo level.'

e) 'Tune': 'A' or 'B' or 'null,' signifying whether the word gets a 'Tune A' final fall, a 'Tune B' question rise, or neither.

f) '# of phrases': one integer for the entire sentence, specifying how many syntactic 'phrases' occur in the sentence.

Default values for all numbered PIs are 0, and the default CR is a fall+rise CR. These PIs occur either on each of the word inputs or on the sentence as a whole (but not on individual syllables or phonemes, since that type of information is not required by the HLS), except where CS applies to a syllable.

Presumably, this level of the total system involves the basic decisions the speaker makes as to how to convey the message through his structuring of
Fo. This procedure may involve some conscious activities, such as emphasis or contrastive shift of accent, as well as more automatic (or 'learned') processes, such as pausing after certain syntactic units and terminating declarative sentences with an Fo fall.

The following should be considered as the algorithm for the HLS, to be used to generate the PIs from syntactical and semantical inputs. The number in parentheses after each rule refers to that section in the text where the Fo observations which led to that rule can be found. The algorithm is summarized in flow-chart form in Figs. 137-146.

A) At the sentence level (Fig. 137):

1) If a statement or exclamation, mark the last word with Tune A, unless the sentence has a tag question, in which case mark the last word with Tune B, and mark the last word before the question with Tune A (e.g., "Joe won, didn't he?") (6.1.1).

2) If a question:

   a) if a yes/no question, mark the last word with Tune B, unless the question offers alternatives, where it gets Tune A and the last word before the last alternative gets a Tune B (e.g., "Do you want coffee or soda?") (6.1.2).

   b) if a Wh-question, mark the last word with Tune A, unless it ends with one or more examples, in which case mark the word before the examples as Tune A and mark the final word as Tune B; if there is more than one example with separate question marks, mark the final word of
each example as Tune B (e.g., "What's for dinner - steak? chicken?") (6.1.3).

c) if a separate, reduced-form alternative question occurs 'after' a yes/no question, or after a Wh-question with examples (e.g., "Do you like Joe? or Sue?"), mark its final word as Tune A (6.1.2.4).

3) If ending in a vocative, give the word before the vocative the same Tune as the vocative, and if Tune A, delete that from the vocative (6.2.3.3).

B) At the phrase level (syntactic effects) (Fig. 138):

1) At non-final clause boundaries:

   a) if an independent clause, give the word preceding each boundary a break of -4 and a CR of 3.

   b) if a dependent clause, give the word before the first boundary a break of -2 and a CR of 1, and give the word before the second boundary a break of -3 and a CR of 2 (6.3.1.1 & 5.3.3.6).

2) At boundaries created by a syntactic transformation:

   a) with a 'focus' transformation, give the last word before the boundary a break of -4 (for clefting and pseudo-clefting), -3 (for there-insertion), or -2 (for dummy-insertion), but only give it a CR of 2 when the focussed phrase follows the boundary (5.3.2).

   b) with preposing, give the word before the boundary a break of -2 and a CR of 1 (the boundary being defined as that between the switched words and the VP) (5.3.1.2).

   c) with a left-offsetting transformation, give the last word in the offset phrase a break of -4, and a CR of 2 (for topicalization) or 3 (for
left dislocation) (6.4.2).

   d) with a right-offsetting transformation, give the last word before the offset phrase a break of -4, but no CR (and give it a Tune A for right dislocation, but not for extraposition) (6.4.3).

   e) with ellipsis, give the last word before the ellipsis site a break of -1 and a CR of 1 (6.5).

3) Within a clause, locate the major syntactic boundaries to receive breaks as follows:

   a) if there are any phrases set-off by punctuation (e.g., parenthetical expressions, vocatives, appositives), place breaks of -3 and CRs of 2 on the words preceding each non-clause boundary (except that appositives in a list and vocatives receive no prior CRs) (6.2.3.3 & 6.4.4).

   b) if the clause varies from the 'basic' subject+VP division (e.g., begins with an introductory PP), place a break of -2 and a CR of 1 on the words preceding the phrase boundaries which deviate from the normal structure (6.2.4).

   c) in the sections of the sentence that remain intact with no breaks, determine where any breaks should be placed as follows:

     i) allocate one break for every 4 content words (i.e., allow one break for stretches of sentence with 4-7 content words, 2 breaks with 8-11, etc.).

     ii) place the breaks at the 'strongest' syntactic boundaries (i.e., the highest in the surface tree), with the restriction that the stretch of sentence be broken into relatively even numbers of words (place one on the last word of the subject, if it contains 2 or more content words;
place one on the last word of each non-final phrase in a co-ordination, if that phrase has 2 or more content words) (6.2.4).

iii) give breaks at conjunction and comma locations values of -2 and CRs of 2; give other remaining breaks values of -1 and CRs of 1 (6.2.4).

iv) place a CR of 2 on a vocative; and if it has Tune A, delete the Tune (6.2.3.3).

d) in stretches of the sentence between already-assigned breaks, assign 'P-units' by giving the first content word in the P-unit a positive break number (+2) and the last a negative number (-2) (if the latter hasn't already been given a bigger number), to the following syntactic phrases (6.2.4):

i) a NP having 2 or more content words and not being contained in another NP in the same stretch,

ii) a VP starting with a verb + one or more PPs, each modifying the last,

iii) a sequence of PPs, each modifying the last,

iv) a short adverbial or adjectival phrase of 2 or 3 content words.

4) In 'parallel' phrases (those conjoined phrases having the same syntactic structure and equal numbers of content words):

a) increase the CR numbers by +1.

b) increase the CR numbers in conjoined structures of more than 2 phrases by another +1 (i.e., a 'list' of 3 or more phrases contains bigger CRs than a list of 2) (5.2.2).
5) The above-assigned CRs should be fall-rise CRs, except in the following categories, where they are monotonic CRs:

a) in Tune B clauses.

b) on the non-final phrases of a co-ordination:

i) if preceded by a quantifier (e.g., "both"), or
ii) if the phrase has only one content word.

6) Within a NP having 3 or more content words and containing no conjunctions or post-modifying PPs, determine which pairs of content words are most closely associated (i.e., are joined at the lowest level in the surface tree); give a 'level' of -1 to the second word of each pair, and a level of +1 to all other content words in the NP (6.6).

7) For the anticipation effect, determine the number of 'phrases' in the utterance, counting each 'simple' NP, VP, and PP in the first clause as 1 'phrase.' Simple 'phrases' contain 1-2 unconjoined content words; phrases conjoined by conjunctions are treated as separate 'phrases.' If an unconjoined phrase has more than 2 content words, add a 'phrase' for each additional 2 content words. If more clauses occur after the first one, add one 'phrase' only for all of them (7.2.1).

C) At the word level (semantic effects) (Fig. 139):

1) Give each word an 'accent' number in accordance with its inherent accent potential as follows (5.1.2):

a) articles

b) conjunctions, relative pronouns

c) prepositions, aux's, B modals, vocatives

0

1

2
d) personal pronouns  
e) finite verbs, demonstrative pronouns  
f) nouns, adjectives, ordinary adverbs, negative contractions  
g) reflexive pronouns  
h) A modals  
i) quantifiers  
j) interrogative words  
k) negative adverbs  
l) sentential adverbs

(In this chapter, words in classes e-l are called 'content words,' and words from classes h-l are 'modality operators' (MOs).) (Any positive contraction assumes the class of its first element.)

2) Adjust the accent number for each word +2 if the word has 2 or more syllables (this is an attempt to give more accent to the rarer words in each form-class). If 2 words in succession function as a compound, reduce the accent number on the second by -5 (5.1.2 & 5.1.3).

3) Modify the accent based upon context:

a) in a sentence with a syntactic transformation:

i) if a 'focus' transformation, increase the accent number on the focussed words (i.e., the content words in the focussed phrase, if any; if none, then the function words with the highest accent number get the increase) by +4 for cleft and by +3 for the other focus transformations, and decrease the numbers of the words not in the focus phrase (except for pseudo-cleft) by -2 (5.3.2).

ii) if preposing, increase the number on the switched words by +2 (5.3.1.2).
iii) if passive, increase the accent number on the verb by +2 (5.3.1.1).

iv) if a right-offsetting transformation, decrease the numbers on the offset content words by -2, and increase the numbers on the remaining content words by +2 (6.4.3).

b) Repetition and Anaphora:

i) if a content word is repeated in a sentence, decrease the accent numbers on the non-initial occurrences by -3, unless the word is successively repeated (e.g., "He will never, never do it"), where the first occurrence has its number increased by +3 (5.2.1.5).

ii) if a non-pronominalized phrase is an anaphoric occurrence of a previous phrase, reduce its accent number by -3, unless one or more items have been mentioned in the prior discourse which have similar semantic features. In particular, if a phrase specifies a subset of a previous item, do not decrease its number; if a superset however, decrease its accent (5.2.1). In a question/answer context, any content words repeated in the answer similarly have their accents reduced by -3 (5.2.1.4).

iii) if a word is a repeat occurrence within the same clause and is not pronominalized, reduce its accent number and that of the previous occurrence by -2 (5.2.1).

iv) if a word or anaphoric referent is repeated in a later clause and it could be elided from the start or end of that clause, and if a dummy adverb (e.g., "also," "too") is present, increase the adverb's accent number by +2 (6.5).

c) in a paragraph, reduce all accent numbers on content words in the third through fifth sentences by -1, and reduce all later accent num-
bers by another -1 (except the accent number for the initial content word in each sentence, which is reduced by -3). Also, if a phrase has several anaphoric occurrences in a paragraph, reduce all numbers beyond the second by another -1 (5.2.1.6).

d) if 2 or more phrases occur in parallel positions (i.e., if they occupy similar positions (e.g., subject, verb) in successive conjoined clauses or phrases, or in a subject and object of the same clause): increase the accent numbers on the non-final parallel words by +2, and on the final one by +1 (5.2.2).

i) in particular, increase the accent numbers in conjoined phrases and in parallel positions in comparison clauses (the content words in such positions get the increased accent, if any present; if none, then the function words).

ii) in conjoined clauses, if an anaphoric occurrence in one clause refers to an element in an earlier clause in a parallel position and they are not related (i.e., the anaphoric phrase refers to some other word, not parallel with it), increase the accent number of the first by +2 and of the second by +5. If, however, they are related, do not increase the accents (i.e., parallel phrases have increased accent only if their elements are similar but not identical) (5.2.2.2).

iii) in clauses with parallel words getting increased accent, decrease the numbers of the non-parallel content words by -1.

e) other semantic effects:

i) if contrastive stress is to be placed on one or more words, raise their accent numbers by +4, and decrease those of the remaining
content words in the sentence by -2 (2.4.1).

ii) if a dummy aux is used without "not" in a Tune A sentence, increase its accent by +7 (5.1.2.1).

iii) if a word other than a modal or aux precedes "not," increase its accent number by +2 (5.1.2.3).

iv) raise the accent numbers of all content words within a quotation by +2, but reduce the numbers of all content words in other embedded clauses and offset phrases by -2 (5.3.3).

v) reduce the accent numbers on content words in an indirect object by -1 (6.2.5).

vi) in sentences with a quantified subject and another MO present, increase the accent number on the quantifier by +2 (5.1.2.2).

8.2) The Low Level System (LLS)

The following is a continuation of the above algorithm, now using for input the output PIs and phonemical data as well, to yield an output Fo contour. Specifically, the LLS accepts as input:

1) the PIs from the HLS.

2) certain information on each individual word:

   a) the number of syllables, and which has lexical stress (e.g., "2nd of 4").

   b) features for each consonant of each syllable: unvoiced, voiced; nasal, liquid, obstruent; with syllable boundary markers.
A) Preliminaries:

1) Assume the speaker whose Fo is being modeled is a 'standard' speaker with an approximate range of 100 Hz and a lowest Fo of 85 Hz, with his BOR being the range 95-110 Hz. At the end of the LLS pass, scale and adjust the Fo contour linearly by the actual amount of the Fo range and lower limit of the speaker (which are two optional LLS inputs).

2) Consider each syllable as receiving an Fo triplet (amount of prior Fo jump/drop, successive amounts of rise/fall in the nucleus, and Fo peak value in the syllable) (e.g., "+10, (+6, -16, +5), 170 Hz").

3) Assign each syllable an accent number by giving the lexically-stressed syllable of each word the accent number of that word (from the PIs). Give all other syllables a value of zero.

4) Define the first syllable with a value of greater than 5 as the 'head' syllable. Designate each syllable with an accent number of 5 or more as an accented syllable (AS), and each with less as an unaccented syllable (US).

5) The procedure for determining the Fo contour consists of obtaining values for the triplet of each syllable. First, the Fo peak for each AS is assigned, then the amounts of rise and fall accents for each AS are assigned, then the CRs are added, and finally the triplets for the USs are given. After the contour is initially defined, phonetic modifications alter the Fo changes and peaks, and divide each positive Fo change (rise accent) into a succession of one Fo jump (prior to the syllabic nucleus) and one Fo rise (during the nucleus), and each negative Fo change (fall accent) into a drop plus fall (Fig. 3a).
6) Divide the sentence into successive, conjoined independent clauses (grouping any dependent clauses with their main clauses), and treat each separately in the following.

B) Fo Peaks (Fig. 140):

1) Initial ('head') peaks:

   a) to a base value of 115, add +10 for each 'phrase' up to a limit of 185.

   b) repeat this for the initial AS in each independent clause in the sentence, but decrease the base value by -8 and the increment by -2 for each successive clause. (The anticipation effect is 'strongest' in the initial clause, and weakens in later clauses.) (7.2.1).

2) Fo 'room':

   a) the Fo difference between the head peak and the top of the BOR (110 Hz) is defined as the Fo 'room' for a Tune A clause; for a Tune B clause, the lower value used is 125 Hz. (A clause is defined as Tune A or B if its last word has a Tune A or B, respectively; if the last word has neither, it is designated Tune A.)

   b) find the 'drop' between successive AS peaks (i.e., peak differentials) by dividing the 'room' by the number of ASs in the clause. If there are 4 or more ASs in the clause, increase the first and next to last 'drop' values by 15%, and decrease the remaining 'drops' by an amount such that the sum of the drops equals the Fo 'room.' Assign peak values to each AS by subtracting the amount of its drop from the preceding AS peak. (These successive peaks follow the upper declination line.) (7.1.1).
3) Modify the peak values:
   a) adjust the peaks in a NP according to the 'level' PIs (proceeding left-to-right):
      i) for each AS with a 'level' number of +1, raise its peak by +40% of the difference between its peak and the prior one.
      ii) for each AS with a 'level' number of -1, lower its peak by -40% of the difference between its peak and the ensuing one (6.6).
   b) adjust the peaks for each AS according to its 'accent' PI: multiply the difference between its accent number and 8 by 10% of the local Fo 'room' (i.e., the difference between its peak and 110), and add this product to the peak. This raises the peaks of words with numbers above 8 and lowers those below 8 (5.1.2).

   C) Rise and Fall Accents on ASs (Fig. 141):
      1) Assign rise accents:
         a) the basic amount of rise accent for an AS is 40% of the local Fo 'room' for that AS.
         b) this amount is altered if the word has a non-zero 'break' number; add 20% of the product of the rise and the 'break' number to the basic rise. (Thus, P-unit initiators gain in rise accent, and terminators lose.)
         c) the head AS gets a rise accent of its peak—110 (Fo being assumed to start from the top of the BOR).
      2) Assign fall accents (i.e., descents, occurring after the rise accent):
a) the basic amount of fall accent for an AS is -20% of the local
Fo 'room' for that AS.

b) in words with non-zero 'break' PIs, add to the descent the
product of the 'break' number and 20% of its local Fo 'room' (note: the
descent should be a negative number).

3) Modify the amounts of accent within a P-unit: if a word has a
zero 'break' number and is preceded by a word with a positive 'break,'
reduce its amounts of accents by -30%. (6.2.4).

D) Phonetic Modifications (Fig. 142):

1) Separation (7.2.2.1): The amount of rise accent an AS gets is
dependent on the number of preceding USs (except for the first AS in a
clause) and on the number of following USs. Thus the number of USs between
2 ASs affects the accent each gets. Consider the 'normal' pattern to be
one US between each AS; this pattern results in no change in the assigned
Fo peaks.

a) If 2 ASs are adjacent (i.e., no USs between them), the rise
accents of both are reduced by -40%, and the first Fo peak is reduced by
-20% of its local Fo 'room,' while the second peak is similarly raised by
+20%; increase the fall accent of the first or the rise accent of the
second so that the end points of the Fo pattern meet.

b) If 2 or more USs separate a pair of ASs, each gets a larger
accent: add 15% more to each of the AS rise accents for one extra inter-
vening US (i.e., for a total of 2 USs), add another 10% for a second US,
and 5% for a third US. More additional USs between ASs have no further
effect on their accents.

c) While 2 or more intervening USs have the same enlarging effect on the adjacent rise accents, they have opposite effects on the sizes of those respective Fo peaks. The more USs preceding an AS peak, the more Fo is allowed to fall prior to it and the lower it gets: for one extra prior US (i.e., for a total of 2 USs), decrease the Fo peak height by -15% of its local Fo 'room'; for a second extra prior US, decrease it by another -10%.

d) Similarly, the more USs following an AS peak, the more opportunity there is for Fo to fall from a higher peak to a low value in time for the next Fo rise. Thus, one extra following US increases the amount of the current Fo peak by +10% of its local Fo 'room', and a second by another +5%.

e) If 3 ASs occur in succession, reverse the order of the medial AS's accents (i.e., place the fall accent first and the rise accent second) (6.2.4).

f) if the word is not inside nor at the end of a P-unit, and 3 or more USs precede its AS, change its rise accent to the difference between its peak value and 105 (since Fo reaches the BOR after 3 USs) (7.1.2.1).

2) Terminal (6.1):

a) if the word has a Tune A or B, and the AS is word-final:

i) if Tune A, increase its descent so that Fo reaches 85 Hz.

ii) if Tune B, add a rise after the AS's descent, so that Fo reaches a value 20% above the biggest prior peak.

b) if the AS occurs in a Tune B clause, transfer 80% of the fall
accent to be additional rise accent.

E) **Continuation Rises** (CRs) (Fig. 143):

1) If a word has a non-zero CR PI, its last syllable receives an Fo change additional to the rise and fall accents, with the amount of the CR being 8 times the CR number (6.3).

2) If the word's CR is monotonic, reduce the fall accent on its AS by 80%; if its CR is fall+rise, increase the fall accent by 30% (6.3.4).

F) **Fo Patterns on the USs** (Fig. 144):

1) Once the Fo patterns on the ASs and for the CRs are given, the rest of the contour is 'filled-in.'

2) The Fo starting and ending points for the ASs can be computed by subtracting the rise and fall accent values, respectively, from the peak in each AS (except in the case that the accents were reversed); any USs that occur between 2 ASs must have Fo patterns that connect the end-point of the first AS and the start-point of the second AS.

3) When one or more USs intervene, if the difference between end- and start-points is positive, decrease the previous fall accent and increase the ensuing rise accent by equal amounts until the difference is zero.

4) 2 basic patterns are followed (6.2.4):
   
a) if the USs occur in a P-unit (i.e., after a syllable with a positive break number and before one with a negative break number), the falling rate is linear, with each successive US getting an equal share of the Fo decrease.
b) if the USs are not in a P-unit, they observe an 'exponential' falling pattern in which the sizes of successive descents decrease:

i) if 3 or more USs occur in sequence, let the Fo difference between the end-point of the first AS and 105 be 'X'; the first US gets a descent of 45% of X, the second 35%, and the third 20%; further USs beyond the first 3 and any USs at the very start of the clause exhibit small rises and falls within the BOR, according to their accent numbers: each gets a rise and fall accent of the same size, viz., the accent number of the syllable times 4 Hz.

ii) if only 2 USs are present between the 2 ASs, give the first 60% of the decrease and the second 40%.

5) **Terminals:** if the word has a Tune A or B, and USs are word-final:

   a) if Tune A, use 85 Hz as the lower Fo value that should be attained during the USs, and divide up the Fo distance equally among the USs.

   b) if Tune B, replace any fall on the last US with a rise to a value +20% above the biggest prior peak.

G) **Division into Jumps and Rises and Local Fo Perturbations** (Fig. 145):

1) Once each syllable has been assigned its corresponding amount of Fo rise and fall, local Fo effects make minor alterations, and also determine how the amount of Fo change per syllable is to be divided between a prior jump or drop and a nucleic rise or fall (Fig. 3a) (7.3).

2) The **syllabic nucleus** in this study was defined as that section of the syllable having energy above 40% of the maximum on that syllable. In effect, the nucleus included the entire vowel, and about half of sonorants
such as /l, r, w, y/, but little of the nasals or voiced obstruents. Thus, for synthesis purposes, prior jumps should take place (between syllabic nuclei) during any obstruents and nasals and during half of any non-nasal sonorants; Fo on these phones consists simply of an extension of the Fo pattern on that syllable.

3) If an unvoiced consonant begins an AS, increase the amount of accents and the peak Fo by +20% each. Depending on the voicing of the initial consonant in an AS, divide the rise accent as follows (7.3):

a) if unvoiced, prior jump = 80%, nucleic rise = 20%

b) if voiced, " " = 20%, " " = 80%

4) The standard division for Fo descents is half fall and half drop after the nucleus. But if an US follows an AS in the same word, voicing has an effect:

a) if one of the consonants between accented vowel and following unaccented vowel is unvoiced, the fall:drop ratio for the AS is adjusted to 1:2.

b) if none of these consonants is unvoiced, the ratio changes to 4:1 (i.e., almost all of the descent occurs in the nucleus), and 30% of the descent is shifted to the next US, if one follows.

H) **Time Synchronization and External Variations** (Fig. 146):

1) In ASs initiating P-units, if an US follows the AS within the same word, use 20% of the accent as a prior jump on the US (6.2.4).

2) In syllables with both rise and fall, distribute each durationally in proportion to its amount, with the restriction that a CR start no earlier.
than halfway through the syllabic nucleus.

3) **Speaker differences**: to adjust the Fo contour for speakers other than the 'standard' one for which the algorithm has been described (7.4.1):

   a) scale all Fo changes (i.e., rises, falls, jumps, drops) by the ratio of the new speaker's range to 100 Hz, and add an Fo offset to all peaks equal to the difference between the new speaker's lowest Fo and 85 Hz.

   b) use a fall:drop ratio appropriate for the speaker.

4) **Speaking rate**: an inherent rate of speech is another speaker-dependent parameter, but varying rates for one speaker had little effect on the Fo contour other than increasing the slopes of the Fo rises and falls (7.4.4).

I) **Post-processing**:

Linear Fo rises and falls have been used in this study because they modelled well and simplified the analysis. However, for actual synthesis, the generated, linearized Fo contour should be smoothed (e.g., by a low-pass filter).

J) **Effects not included**: a number of Fo effects have been noted in Chapters 5-7 which have not been included in the algorithm, to keep the program simpler, either:

   1) because the effects were subtle or optional:

      a) that the lower declination line (and hence the BOR) slowly declines with time.

      b) that the speaker may shift accent from "not" to a modal if
they occur in sequence.

2) or because the effects were difficult to quantify in terms of an algorithm:

a) that common or 'gnomic' expressions and idiomatic phrases received decreased accent.

b) that words 'semantically related' to other words in the sentence received decreased accent.

8.3) An Example

Since the algorithm is somewhat complex, one example is worked out in detail below; this one and others are illustrated in Fig. 147. The predicted contour in each case is compared to the actual contour for a sentence recorded in set H, which was not used to determine the algorithm or its parameters. In the ensuing description and in Fig. 147, the code in parentheses refers to that section of the algorithm which contains the rule currently being applied at each step.

8.3.1) High Level System

Consider the sentence "Joseph basically is a good man." Being a statement, the sentence ends with "man" getting a Tune A fall (A1). Containing 4 content words ("Joseph," "basically," "good," "man"), it should have one Fo break (B3c), which is placed between "basically" and "is." "good man" is assigned a P-unit (B3d). The sentence contains 3 'phrases' ("Joseph," "basically," "good man") (B6). The 6 words get inherent accent numbers of: 7, 14, 2, 0, 7, & 7, respectively (C1), but then "Joseph" and
"basically" get theirs increased by +2, since they are multisyllabic (C2).

8.3.2) Low Level System

With 3 'phrases,' the sentence has a head peak of 145 (115 + 3 * 10) (B1). The Fo 'room' is 35 (145 - 110), and the successive peak differences on the content words are -10, -8, -10, and -7, leading to original peaks of 145, 135, 127, and 117, respectively (B2). To modify each peak by the word's accent number, calculate the local Fo 'room' of each (35, 25, 17, and 7, respectively), take 10%, and multiply by the accent number -8, getting new peaks of 149, 159, 125, and 116, respectively (B3b).

The original rise accents are 40% of each content word's revised local Fo 'room' (+16, +20, +6, & +2) (ClA). This is altered by the 'break' numbers for "bas-", "good," and "man," which have their accent numbers changed to +16, +8, and +1, respectively (Clb), while the initial word has its rise accent changed to +39 (Clc). The original fall accents are -20% of each content word's local Fo 'room' (-8, -10, -3, and -2) (C2a), but as above the last 3 are changed by the 'break' numbers, to -20, 0, and -4 (C2b).

Separation modifies the accents and peaks of the last 3 ASs because the middle 2 are separated by 4 USs ("basically is a good") and the last 2 have no separation ("good man") (D1). The rise accent for "bas-" increases by +30% to +21 (Dlb), while its peak increases +15% to 166 (Dld). Similarly, the rise accent for "man" decreases by -40% to +1, and its peak increases
+20% to 117 (Dla). "good," being affected by 2 separation rules, has a rise accent change of +30%-40% (= -10%) to 7 (Dla-b), and a peak change of -25%-20% (= -45%) to 118 (Dla & c). Finally, "good," following 4 USs, has its rise accent changed to +13 (118 - 105) (Dlf), while the fall accent on "good" was increased to -2, to make the Fo endpoints in "good man" meet (Dla). Since "man" has Tune A, its fall accent is increased to -32 (117 - 85) (D2a).

The CR at the end of "basically" (on its last syllable) is fall+rise (C5 in the HLS) and equal to +8 (El), and the fall accent on "bas-" is increased by +30% to -26 (E2).

Between the first 2 ASs ("Joseph bas-") is one US, but the end-points of the ASs (141 & 145, respectively) lead to a positive difference (which is not allowed in USs), so the fall accent of "Jos-" is decreased by 2 (to -6) and the rise accent of "bas-" is increased by 2 (to +23), leading to common end-points of 143, and zero Fo change for "-eph" (F3). Between the middle 2 ASs ("basically is a good") are 4 USs, to cover the Fo distance between the end-points of "bas-" and 105 (140 - 105 = 35) (F4bi); "-sic-" gets -16 (45%), "-ally" gets -12 (35%), "is" gets -7 (20%), and "a" gets 0.

Dividing up each rise accent into jump+rise, each AS has a voiced initial consonant and thus gets 20% jump and 80% rise: "Jos-" (+8, +31), "bas-" (+5, +18), "good" (+3, +10), and "man" (0, +1) (G3b). For all syllables, each descent is divided into fall+drop, equally for: "-eph"
(0, 0), "-ic-" (-8, -8), "-ally" (-6, -6), "is" (-8, -7), "a" (0, 0), and "good" (-1, -1) (G4). (Note: "is" has -15 descent to include the +8 CR occurring immediately prior to it.) "man" has its -32 descent fully within the nucleus, because it is sentence-final. "Jos-" and "bas-" split their descents 1:2, because USs are word-final there, after the ASs (G4a).

8.3.3) Results

The generated and actual Fo contours are displayed in Fig. 148a. Several differences can be noted, especially in the Fo peaks (e.g., the predicted peaks averaged -11 lower than the actual ones), but the overall pattern is similar, and the crucial rises and falls occur at the same locations in each. Considering the amount of intra-speaker variation there is and the wide set of English this algorithm is attempting to cover, that the 2 contours do not match exactly is not surprising. However, a synthesized version with the predicted contour would likely sound little different from one using the actual contour. Other examples are also shown in Figs. 147-148.
9) **Summary of Thesis:**

An algorithm to generate Fo contours by rule for English has been presented, based upon the observations of many utterances recorded by several speakers. By controlling these sentences for syntax, semantics, and phonetics, a framework was established in which to model Fo patterns. Consistent changes in the Fo contours were related to differences in the linguistic message and in the phonetic composition of the sentences. Deviations which occurred on repeated utterances of the same and similar sentences were attributed to free variation or 'noise,' and helped to define the parameters of the Fo contour that were most relevant (i.e., those not in free variation).

Based upon perceptual studies of the relevance of Fo movements to pitch and intonation, upon studies describing the manner of control of Fo by the speaker, and upon observations of the data, certain quantifiable measures in the Fo contour were proposed as those factors most important linguistically and phonetically. Each word was defined as having an amount of 'accent' in proportion to how much Fo rose and/or fell on the lexically-stressed syllable of that word, and to how high that word's peak Fo value was compared to others in the utterance.

It was proposed that, in varying his Fo, the speaker follows 2 rules:

1) give the words least predictable in context the biggest amounts of accent, and

2) use sharply rising Fo at the start and sharply falling Fo at the
end of syntactic phrases.
These rules serve 2 functions: that of semantically highlighting the words
the speaker considers important to the message, and that of segmenting the
utterance into syntactic phrasal units. Both functions have as their
objective an improvement in the efficiency of the communication of speech,
in that they ease the listener's perceptual load: by keying on those words
marked with large accents and by establishing relationships among the words
according to how the utterance is divided, the listener has a much easier
task than with synthesized monotone speech.

The linguistic approach of this thesis followed Hallidav's view of
language having 3 main functions: conveying objective content (ideational),
expressing the speaker's attitude toward the context (interpersonal), and
relating the content of different sentences to one another (textual). The
few prior acoustical studies of Fo in sentential utterances have primarily
focussed upon just the ideational component and were usually very limited
in scope, using simple sentences with nouns, verbs, and adjectives
(Lieberman, 1967; Olive, 1975; Maeda, 1974). Some have briefly examined
Fo in its textual function, by using sentences in paragraphs or in question
contexts (Coker & Umeda, 1971; Wode, 1972), and others have looked at Fo
patterns in spontaneous speech (Peck, 1969) and in relationship to muscle
activity (Atkinson, 1973); but I believe this study is the first to
examine Fo in all 3 language areas with a wide corpus of sentences covering
a substantial amount of syntactic, semantic, and phonetic phenomena. To
establish the relevant Fo patterns for a speech synthesis system, a wide
set of controlled sentences had to be used.

Due to the construction of the vocal tract and associated musculature, the speaker is limited in the types of Fo patterns he can produce without excessive effort. Thus, several phonetic factors were interpreted as forming a 'baseline' Fo pattern upon which linguistic Fo deviations were superimposed. Viewing the Fo contour hierarchically, the global pattern in most utterances had a gradually-declining shape, and (at increasingly more local levels) the syntactic rises and falls occurred at the phrase level, semantic accenting of important words at the word level, and phonetic perturbations at the syllable and phoneme level.

Within this framework, the speaker apparently adopts a strategy of deviating from the 'normal' pattern to signal some linguistic or phonetic message to the listener. Against a gradually-falling Fo pattern, the rises and sharp falls on words with large accents signalled both that the words on which these occurred were important and that syntactic units were being opened or closed. On a word, the amount of Fo deviation from the 'norm' can be taken as a measure of the 'importance' a speaker judges that word to have.

Syntactically, the utterance was segmented by Fo 'breaks' (fall+rise patterns) at major syntactic boundaries. These rises and falls were located on the lexically-stressed syllables of important words in order to semantically emphasize those words, but it was the direction of the
Fo change that signalled the syntax. Other deviations from the normal Fo pattern included the use of Fo rises late in a word, either as a 'continuation rise' (to signal the listener that further important words were yet to come in the utterance, and/or to indicate that what was just uttered was a non-final member of a 'list') or as a 'question rise' (to signal the listener that a yes-or-no answer is desired). In such yes/no questions, Fo also deviated from the 'norm' in that it remained high throughout the utterance. These rises were in opposition to the normal fall to a very low Fo at the end of most utterances.

These syntactic rises and falls were also specifically used to resolve syntactically-ambiguous sentences, to separate 'topic' from 'comment' in sentences with left-offset transformations, and to mark punctuation and those boundaries created by other syntactic transformations (in which a phrase is set-off from the rest of the sentence).

The amounts of the rises and falls on a word were determined by the degree of importance the speaker attributed to that word. Each word had an inherent 'importance' value which was modified in the context of a sentence or discourse. The open-class content words were more important than the closed-class function words, and words from bigger classes were more important than those from smaller ones. Words expressing the interpersonal role of language were more important than those involved in the ideational function. Within a class, the rarer words were more important than the more common ones.
In context, the inherent importance of a word was altered. If the word was repeated or anaphorically referred to, its value to the message and its accent decreased. If it was focussed upon by a syntactic transformation or placed in 'parallel' syntactic constructions (such as comparisons or co-ordinated phrases), the word's accent increased and the accents of other 'unfocussed' words in the utterance decreased.

Fo contour production can be viewed at 2 levels: a high, 'psychological' level, at which the semantic and syntactic objectives of the speaker are initiated in terms of broad vocal cord commands of the type "increase accent on word X" or "place a sharp fall on word Y," and a low, 'physiological' level, at which these commands are combined with the phonemic composition of the sentence to actually implement the rises and falls, with certain phonetic modifications such as: reduction of accent when accented words are too close or when more words in a sentence are receiving accent, increased Fo levels when sentences are longer, and local increased Fo perturbations with unvoiced consonants.

Speakers were found to have considerable freedom in varying Fo within the constraints of specific linguistic Fo patterns. There appeared to be a trade-off between minimizing effort by reducing the amount of Fo movement and increasing Fo movement to help convey information; the speaker economizes by using as much Fo variation as required by the context of the utterance.
In the future, the Fo algorithm presented will be tested in more
detail and improved. While the relationship of Fo patterns to muscle
activity is important to fully understanding speech, I believe further
perceptual studies of the relevant aspects of Fo are needed and will
bring the greatest rewards. By varying certain parameters within the
Fo algorithm, listeners can be asked whether the utterance sounds
'natural,' 'grammatical,' etc., or whether 2 patterns differ. However,
without first establishing those Fo patterns used by natural speakers
consistently in utterances (as has been done in this thesis), it would
be difficult to discover those Fo parameters which would lead to the
best results.
Paras in Set C:

It was a very hot day for a drive to the countryside. Nevertheless, Joe was in a rush to get out. (1) Joe had eaten his dinner with great speed. (2) He had earlier boiled some water for his coffee. Now, (3) he drank his coffee without thinking.

Bob, the chauffeur, took some sandwiches in his car. (4) He quickly ate the small meal on his way. Today, there was no time for a slow dinner. By prior arrangement, Bob and Joe had agreed to a race to the garage. With no delay, (5) Bob found the way through town. (6) The race was actually won by a nose. Joe was in his car moments before his chauffeur, Bob, showed up. Joe said, "Let's go. (7) The church bells had already been rung by some boys. That means we're late." This indeed was a special day. (8) Joe was seldom driven by the chauffeur. Most of the time, he walked.

But today, it was a trip to the race track. "The horses should run during the morning. That way they'll be ready for post-time," Joe mused. Viewing a nearby farm, Joe watched, as (9) the seeds were sown by the farmer's son. "That brings back memories," he thought.

Paras in Set D:

I) A group of freshmen were talking in the lounge. The conversation drifted to Joe Smith, who was sitting across the hall. (1) Joe was studying his books, and thus was oblivious to the outside world. In the group, Bob asked whether Joe had signed the petition being circulated among the students. Bob was told that it had just been placed in his mailbox that morning, and that, as yet, Joe might not have read the statement. So it was likely that he had not signed it.

Just then, Sue came in without noticing Joe in the other room, and she asked, (2) "Has Joe been studying his books?" Bob responded by pointing across the hall, and saying that, as far as he knew, (3) Joe may have been studying his books all day.

II) Rumors were buzzing all over campus. (4) "Might the boys have been studying their books?" was the question on everyone's lips. Since the boys hadn't been seen the whole day, no one knew for sure. One rumor had it that (5) all the boys might have studied their books. But that was surely too far-fetched to be believed. Another said that, while (6) some boys might not have studied their books, many had done so. This was more believable, but even this was hard for the old-timers to accept. The idea that (7) many boys might study their books was a totally alien concept to them. They had a more lenient attitude toward the girls though; when someone mentioned that (8) Josephine might have studied her books, they admitted that possibility.
III) Since he was not an industrious person, it wasn't surprising that (9) Joe might not have studied his books. Everyone knew that (10) Joe should study his books, and they told him so frequently, but he wouldn't listen. He would compare his study habits to others', and mention that (11) some boys might study their books in the morning, and others in the afternoon, but that he liked to be unpredictable. Everyone knew that evening was the time for other activities, yet (12) Joe might have even studied his books then; he was that type of person.

Paragraphs in Set F:

1. Joe went to the store to buy some food. When he got home, Joe boiled the noodles he'd bought.

2. Jane was studying her history books yesterday. While studying her books, Jane heard her room-mate returning from the store. Mary had bought some books at the store, and showed the books to Jane. Jane looked at the books, and said that they were cheaper than her history books.

3. House painting is an easy task if done properly. The painter should use bristle brushes and an oil paint. If the painter does not use a bristle brush to apply the first coat of paint, the paint may flake and peel upon drying. When using oil paint, one should have a dry, clean surface to start with. If the surface is dirty, a coat of paint will not last long after drying. After use, the paint brushes must be cleaned before being allowed to dry.

4. Joe went to the library with his medical books. When he arrived at the library, Joe studied the medical books.

5. Susan and Robert decided to remodel the living room in their house. Susan moved the sofa, and then rolled up the carpet in the living room. Robert carried the carpet out to the porch, and placed it next to the sofa. Susan had earlier covered the sofa with a cloth, and now laid some of the lamps on it. Susan then tripped over the carpet, and asked Robert to move the carpet off the porch. Carrying out some more rugs, Robert agreed with Susan that the porch was too crowded, and so he removed the carpet.

6. Joe went to the store to buy some noodles. When he got home, Joe boiled the noodles he'd bought.

7. Joe and Sue were going to the library. Joe brought his medical books, and Sue carried her biology books. When they arrived at the library, they studied the medical books.
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Linguistic References:


Journal Abbreviations:

BSTJ - Bell System Technical Journal
ICA - International Congress on Acoustics
IPO - Institute for Perception Research
ICPS - International Congress of Phonetic Sciences
IEEE Trans. on A & E - IEEE Transactions on Audio & Electroacoustics
IEEE Trans. on ASSP - IEEE Transactions on Audio, Speech, & Signal Processing
J of L - Journal of Linguistics
J of P - Journal of Phonetics
JASA - Journal of the Acoustical Society of America
L&S - Language and Speech
Lang - Language
LI - Linguistic Inquiry
MIT-RLE-QPR - MIT Research Lab of Electronics - Quarterly Progress Report
PCLS - Proceedings of the Chicago Linguistic Society Meeting
PICL - Proceedings of the International Congress of Linguists
STL-QPSR - Speech Transmission Laboratory Quarterly Progress Status Report
WPP - Working Papers in Phonetics
FIGURES

The majority of the figures are of 2 types: actual Fo plots (for which no legend is given below, since they are self-explanatory) and linearized, averaged Fo plots (for which legends are given below). See Section 3.2.1 for a detailed description of these plots.

Legends:

1) Linguistic division of the sentence.

2) Typical computer-generated Fo plot from read speech. In this and all ensuing figures, the vertical axis represents fundamental frequency (Fo) in Hz and the horizontal axis, time in milliseconds. In this figure, the time axis is marked off in 200 msec intervals. The circles represent Fo values, spaced every 10 msec; the continuous curve at the bottom displays the linear amplitude of the utterance, obtained by taking the maximum value of the 10 KHz-sampled waveform of speech over every 10 msec section. The straight lines drawn through the circles denote the linearized abstraction of the actual data. Such abstractions form the basis of the data for each of the plots in the remaining figures. The Fo data in this figure has been median-smoothed to eliminate deviant data points (Pabiner et al, 1975).

3) Three forms of Fo accent. Each plot shows a portion of a schematized contour, for which Fo is drawn for 4 syllables as a piecewise-continuous line, with that for the AS drawn heavier than that for the surrounding USs. Plot a shows the most common type of primary accent, that caused by an upward obtrusion of Fo. As a quantifier of the degree of rise accent, the basic measure was chosen to be the sum of the Fo jump between syllabic nuclei and the amount of Fo rise during the AS; the degree of ensuing Fo fall and drop constitutes the amount of fall accent a syllable has. Plot b illustrates a secondary type of primary accent, that caused by a steep fall; here the fall accent is larger than the rise accent. Plot c exhibits the prototypical "secondary" Fo accent, where the secondarily-accented syllable interrupts the more rapid fall of the surrounding USs, with a span of more level Fo; the amount of secondary accent is measured by comparing the amount of fall-off on the AS (fall-off$_2$) with those of the adjacent syllables (fall-offs$_{1,3}$).

4) Hierarchical levels of Fo. Plot a shows the prototypical pattern of the sentential utterance, the highest level of the Fo contour. Plot b exhibits the cumulative Fo pattern including the effects at the clause or phrase level; segmenting of the contour by "continuation rises" occurs at this level. Plot c shows the additional effects of Fo at the word level, where individual word accents occur. Plot d illustrates a typical, complete Fo contour, including all levels of Fo effects; the phonemic effects
of Fo are manifest in the continuity breaks of the curve, representing unvoiced sections of speech.

5) Effect of initial consonant voicing.

6) Three types of Sub-contours (SCs). Plot a shows the basic SC; plot b has a SC containing a secondary (as well as a primary) accented syllable (AS); plot c shows a SC containing 2 ASs, one with an Fo rise (at the start of the SC) and one with a fall (at the end). The primary ASs are marked with asterisks.

7) Simplified Fo contour with 4 ASs. The second SC contains 2 of the ASs, in the form of a double rise.

8) Distributions of Fo values. In Figs. 8-13 & 133-135, plots of Fo values taken from several utterances are displayed as histograms, with Fo on the horizontal axis quantized to 2 Hz increments. Means are indicated by 'x̄' and standard deviations by 'SD.' The symbols are:

   a)  c "Say" - final Fo value
   b)  x word X - peak Fo
   c)  & "instead" - peak Fo

9) Distributions of rise accent:

   a)  o word X (stressed on first syllable & unvoiced)
   b)  × word X (stressed on first syllable & voiced)
   c)  & word X (stressed on second syllable)
   d)  + word X (monosyllabic & unvoiced)
   e)  * word X (monosyllabic & voiced)
   f)  $ "instead"

10) Distributions of fall accent on the AS of word X:

   a)  o (stressed on first syllable & unvoiced)
   b)  × (stressed on first syllable & voiced)
   c)  $ (consisting of 2 separate words)
   d)  @ (not decomposable into 2 words)
   e)  & (stressed on second syllable)
   f)  + (monosyllabic & unvoiced)
   g)  * (monosyllabic & voiced)

11) Distributions of Fo fall during the second, unaccented syllable of word X:

   a)  o (first syllable unvoiced)
   b)  x (first syllable voiced)
12) Distributions of F0 fall-off on first syllable of "instead":

a) o fall-off, after X stressed on first syllable
b) x fall, after X stressed on second syllable

13) Distributions of F0 fall-off on first syllable of word X (when second syllable was stressed):

a) o descent in word X
b) x prior drop to word X

14) F0 contours for sentences with no auxiliary verb or with a positive contraction. The symbol codes, with the number of F0 contours represented by a single plot denoted by a number in parentheses, are as follows:

a) △△△ (2) "JOE"
b) ——— (2) "JOE" - positive contracted aux

Capital letters are used to note primary-accented words in the legend of each figure in places which might otherwise be ambiguous. Also, in many figures, letter codes were placed before the start of certain words: A - adverb, N - negative, X - auxiliary verb, C - negative contraction, M - class A modal, B - class B modal, P - pronoun, Q - quantifier, and V - main verb. The latter 3 codes are used only when ambiguity might result, whereas the others are used throughout.

16) F0 contours for sentences with one aux-verb:

a) △△△ (15) "JOE"+aux
b) ——— (4) "JOE"+MODAL (voiced)
c) o o o (2) "JOE"+MODAL (unvoiced)
d) □□□ (4) "JOE"+DUMMY
e) ——— (1) "JOE"+NEGATIVE CONTRACTION (voiced)
f) - — — (2) "JOE"+negative contraction (unvoiced)

17) F0 contours for short sentences by 3 different speakers:

a) △△△ (15) "JOE"+aux (JA)
b) ——— (4) "JOE"+MODAL (JA)
c) □□□ (9) "JOE"+aux (KNS)
d) ——— (2) "JOE"+MODAL (KNS)
e) o o o (5) "JOE"+aux (ML)
f) - — — (3) "JOE"+MODAL (ML)

The letters in parentheses refer to the speaker's initials in this and other figures. The use of the symbol "∅" in brackets indicates the lack of a syllable in that sentence position, in one or more of the F0 plots.
19) Fo contours for sentences with a 2-word aux-group (accent on the second):
   a) △△△ (2) "JOE"+aux+aux
   b) ______ (16) "JOE"+aux+"NOT"
   c) _____ (6) "JOE"+modal+"NOT"

20) Fo contours for sentences with a 2-word aux-group (accent on the first):
   a) △△△ (2) "JOE"+aux+aux
   b) ______ (11) "JOE"+MODAL (voiced)+aux
   c) ○ ○ ○ (1) "JOE"+MODAL (unvoiced)+aux
   d) □ □ □ (3) "JOE"+modal+aux
   e) ______ (3) "JOSEPH"+MODAL+aux
   f) ----- (2) "JOSEPH"+Bmodal+aux

21) Fo contours for sentences with a 2-syllable aux-group:
   a) △△△ (2) "JOE"+aux+aux
   b) ______ (7) "JOE"+NEGATIVE CONTRACTION (voiced)
   c) ○ ○ ○ (4) "JOE"+NEGATIVE CONTRACTION (unvoiced)
   d) ----- (4) "JOE"+negative contraction

25) Fo contours for sentences with a 3-word aux-group (accent on the second):
   a) △△△ (2) "JOE"+aux+"NOT"+aux
   b) □ □ □ (10) "JOE"+modal+"NOT"+aux
   c) +++ (2) "JOE"+modal+"NOT"+aux+aux
   d) ______ (2) "JOSEPH"+Bmodal+"NOT"+aux
   e) ----- (2) "JOSEPH"+modal+"NOT"+aux

26) Fo contours for sentences with a 3-word aux-group (accent on the first):
   a) △△△ (3) "JOE"+MODAL+aux+aux
   b) ______ (5) "JOE"+MODAL+negative+aux
   c) ○ ○ ○ (2) "JOE"+NEGATIVE CONTRACTION (unvoiced)+aux

29a) Fo contours for sentences with quantified subjects:
   a) △△△ (11) QUANTIFIER+"boys"+MODAL
   b) □ □ □ (12) QUANTIFIER+"boys"+MODAL+aux
   c) ______ (10) QUANTIFIER+"boys"+modal+NEGATIVE+aux
   d) _____ (4) QUANTIFIER+"boys"+MODAL+negative+aux
29b) Fo contours for sentences with several MOs by 3 different speakers:

a) △△△ (12) QUANTIFIER+"boys"+MODAL+aux (JA)
b) ——— (10) QUANTIFIER+"boys"+modal+"NOT"+aux (JA)
c) □□□ (6) QUANTIFIER+"boys"+MODAL+aux (KNS)
d) ——— (5) QUANTIFIER+"boys"+modal+"NOT"+aux (KNS)
e) o o o (5) QUANTIFIER+"boys"+MODAL+aux (ML)
f) ——— (4) QUANTIFIER+"boys"+modal+"NOT"+aux (ML)

32) Fo contours for quantified subjects (plots a-f, left side) and simple subjects (plots g-i, right side):

a) △△△ (6) "ALL the boys"
b) □□□ (6) "MANY boys"
c) o o o (8) "BOTH boys"
d) ——— (7) "SOME boys"
e) ——— (7) "THESE boys"
f) +++ (3) "NO boys"
g) △△△ (32) "JOE"
h) ——— (5) "JOSEPH!"
i) +++ (4) "JOSEPHINE"

33) Fo contours for short sentences by 3 different speakers:

a) △△△ (2) "BOYS"+aux (JA)
b) ——— (2) "BOYS"+MODAL (JA)
c) • • • (2) "BOYS"+QUANTIFIER (JA)
d) □□□ (1) "BOYS"+aux (KNS)
e) ——— (1) "BOYS"+MODAL (KNS)
f) +++ (1) "BOYS"+QUANTIFIER (KNS)
g) o o o (1) "BOYS"+aux (DO)
h) ——— (1) "BOYS"+MODAL (DO)
i) • • • (1) "BOYS"+QUANTIFIER (DO)

34) Fo contours for sentences with medial quantifiers:

a) △△△ (2) "BOYS"+aux
b) ——— (2) "BOYS"+MODAL
c) ——— (2) "BOYS"+aux+QUANTIFIER
d) ——— (2) "BOYS"+modal+QUANTIFIER

39) Fo contours for sentences with quantified objects:

a) △△△ (1) "JOSEPH"+MODAL+aux+VERB+"these"+"BOOKS"
b) ——— (4) "JOSEPH"+MODAL+aux+VERB+QUANTIFIER+"BOOKS"
c) □□□ (3) "JOSEPH"+MODAL+aux+VERB+"his"+"BOOKS"
40) Fo contours for sentences with a sentential adverb in pre-aux-group position:

a) △△△ (11) "JOE"+ADVERB+MODAL+aux
b) ——— (10) "JOE"+ADVERB+modal+NEGATIVE+aux
c) ——— (2) "JOE"+ADVERB+MODAL+negative+aux

To represent a single Fo curve for the adverbs in these figures, the Fo rises/falls were averaged within each section. However, since some of the adverbs lacked the first and/or last section (i.e., lacked USs before and/or after the AS), it was necessary to treat their missing sections as having zero change in Fo and zero duration; thus the durations and amounts of Fo change (but not the slopes) for the exterior sections of each adverb's Fo curve are disproportionately smaller than that of the middle section containing the AS.

42) Fo contours for sentences with a sentential adverb after the modal:

a) △△△ (10) "JOE"+MODAL+ADVERB+aux
b) ——— (11) "JOE"+MODAL+ADVERB+"NOT"+aux

44) Fo contours for sentences with a sentential adverb in post-aux group position:

a) △△△ (13) "JOE"+MODAL+aux+ADVERB
b) ——— (6) "JOE"+modal+"NOT"+aux+ADVERB
c) ——— (4) "JOE"+MODAL+negative+aux+ADVERB
d) ——— (1) "JOE"+MODAL+"NOT"+aux+ADVERB

46) Fo contours for modals, negatives, and sentential adverbs:

a) △△△ (34) MODAL (+aux)
b) □□□ (27) modal (+"NOT"+aux)
c) ◯ ◯ ◯ (7) MODAL (+"not"+aux)
d) ——— (27) (modal+) "NOT" (+aux)
e) ——— (7) (MODAL+) "not" (+aux)
f) △△△ (13) "THEN"
g) ◯ ◯ ◯ (8) "SIMPLY"
h) □□□ (6) "EVEN"
i) ——— (14) "ACTUALLY"
j) ——— (6) "OBVIOUSLY"
k) ——— (2) "CONSEQUENTLY"
l) + + + (12) "PERHAPS"
m) x x x (7) "OCCASIONALLY"

Plots a-e are on the left side, and plots f-m are on the right. Words in parentheses indicate the unploted lexical context for the modal or negative, for which Fo is plotted.
48) Fo contours for sentences with varied subjects and modals:

a) △△△ (3) "JOSEPH"+Bmodal+"NOT"+aux+ADVERB
b) ——— (7) QUANTIFIER+"boys"+bmodal+"NOT"+aux+ADVERB
c) ——— (6) QUANTIFIER+"boys"+MODAL+"NOT"+aux+ADVERB

52) Fo contours for the same sentence in citation versus question-answer context:

a) △△△ (2) "A farmer was eating the carrot."
b) ——— (1) (What was the farmer doing?) "The farmer was eating the carrot."
c) + + + (1) (Who was eating the carrot?) "The farmer was eating the carrot."
d) o o o (1) (What was the farmer eating?) "The farmer was eating the carrot."
e) ——— (1) (What was the farmer doing with the carrot?) "The farmer was eating the carrot."

56) Fo contours for sentences in citation versus question-answer context:

a) △△△ (2) "It was the farmer who was eating the carrot."
b) o o o (2) (Who was that?) "It was a farmer who was eating a carrot."
c) ——— (2) (Who was eating a carrot?) "It was a farmer who was eating a carrot."

57) Fo contours for sentences with a co-ordinated noun phrase:

a) △△△ (2) "He bought a red car and a blue car."
b) o o o (2) "He bought a red car and a blue one."
c) ——— (2) "He bought a red car and a red blouse."

61) Fo contours for the second clause of the sentence "When he got home, Joe boiled the noodles he'd bought" in citation versus paragraph context:

a) △△△ (2) in citation
b) o o o (2) preceded by the sentence "Joe went to the store to buy some food."
c) ——— (2) preceded by the sentence "Joe went to the store to buy some noodles."

73) Fo contours for similar sentences without and with focus transformations:
425

a) △△△ (2) "A farmer was eating the carrot."
b) □ □ □ (4) "It was a farmer (who was) eating the carrot."
c) - - - (2) "There was a farmer eating the carrot."

74) Fo contours for similar sentences with focus transformations:

a) △△△ (4) "A farmer was the one (who was) eating the carrot."
b) - - - (2) "What the farmer was doing was eating a carrot."

78) Fo contours for similar sentences without and with focus transformations:

a) △△△ (1) "A cow was eating the carrot."
b) □ □ □ (1) "A gazelle was eating the carrot."
c) ○ ○ ○ (2) "There was a cow eating the carrot"; "It was a cow that was eating the carrot."
d) - - - (2) "There was a gazelle eating the carrot"; "It was a gazelle that was eating the carrot."

79) Fo contours for sentences with the dummy-insertion focus transformation:

a) △△△ (1) "A cow was the one who was eating the carrot."
b) □ □ □ (1) "A gazelle was the one who was eating the carrot."

86) Fo contours for sentences with focus transformations:

a) △△△ (2) "Eating the carrot was a farmer."
b) □ □ □ (4) "The one (who was) eating a carrot was a farmer."

87) Fo contours for similar sentences with clefting and pseudo-clefting focus transformations:

a) △△△ (2) "It was eating a carrot that the farmer was doing."
b) □ □ □ (2) "Eating a carrot is what the farmer was doing."

88) Fo contours for similar sentences without and with there-insertion:

a) △△△ (2) "Something keeps stealing the bait."
b) □ □ □ (2) "There's something that keeps stealing the bait."

89) Fo contours for similar sentences without and with clefting:

a) △△△ (2) "Because Joe bought a new car, we went for a ride."
b) □ □ □ (2) "It was because Joe bought a new car that we went for a ride."
90) Fo contours for initial, matrix clauses of two-clause sentences:

a) △△△ (16) "BRUCE"

b) □□□ (10) "BRUCE"+MODAL+aux

c) ——— (4) "BRUCE"+modal+NEGATIVE+aux

91) Fo contours for initial, matrix clauses of two-clause sentences:

a) △△△ (8) "BRUCE"+ADVERB

b) □□□ (4) "BRUCE"+MODAL+aux+ADVERB

c) ——— (2) "BRUCE"+modal+NEGATIVE+aux+ADVERB

92) Fo contours for final, embedded clauses of two-clause sentences, compared to clauses in other contexts; lexical material in brackets below indicates words in the unpunctuated clause:

a) △△△ (10) "BRUCE"+MODAL+aux [CLAUSE]

b) □□□ (3) "JOSEPH"+MODAL+aux

c) ——— (2) [NOUN+VERB] "JOSEPH"+MODAL+aux

d) ——— (2) [NOUN+ADVERB+VERB] "JOSEPH"+MODAL+aux

93) Fo contours for clauses in three contexts:

a) △△△ (4) "BRUCE"+MODAL+aux+ADVERB [CLAUSE]

b) □□□ (4) "JOSEPH"+MODAL+aux+ADVERB

c) ——— (2) [NOUN+VERB] "JOSEPH"+MODAL+aux+ADVERB

94) Fo contours for similar sentences without and with embedded clauses:

a) △△△ (2) "That fish is tasty."

b) ○○○ (2) "That fish is tasty is true."

c) ——— (2) "It's true that fish is tasty."

96) Fo contours for similar sentences with two clauses:

a) △△△ (2) "Fred won the race, which surprised me."

b) ——— (2) "That Fred won the race surprised me."

99) Fo contours for yes/no questions:

a) △△△ (4) aux+NP+aux ?

b) ——— (4) MODAL+NP+aux+aux ?

c) ——— (4) NEGATIVE CONTRACTION+NP+aux ?

106) Fo contours for Wh-questions:

a) △△△ (2) aux+NP+aux ?

b) □□□ (2) aux+NP+NEGATIVE+aux ?

c) ——— (4) MODAL+NP+aux ?

d) ——— (2) NEGATIVE CONTRACTION+NP+aux ?
119) Fo contours for similar sentences without and with a left-offsetting transformation:

a) \(\Delta \Delta \Delta\) (4) "This flounder should be cooked carefully."
b) \(\Delta\) (2) "This flounder you should cook carefully."
c) \(+ + +\) (2) "This flounder, it should be cooked carefully."

122) Fo contours for similar sentences without and with a right dislocation transformation:

a) \(\Delta \Delta \Delta\) (2) "You should carefully cook the flounder."
b) \(\Delta\) (2) "You should carefully cook it, the flounder."

128) Fo contours for similar sentences without and with ellipsis:

a) \(\Delta \Delta \Delta\) (2) "Robert hasn't bought the car yet, but he will buy it later today."
b) \(\Delta\) (2) "Robert hasn't bought the car yet, but he will later today."

131) Simplified Fo contours with 1, 2, or 3 SCs, illustrating the 'anticipation' and 'carrier' effects.

132) Variations within a SC, depending upon the location of the peak Fo.

133) Distributions of Fo peaks:

a) \(o\) "Bears"
b) \(x\) "live"
c) \(\&\) "Arctic"

134) Distributions of rise accents and continuation rises:

a) \(o\) CR of "gulls"
b) \(x\) accent on "live"
c) \(\&\) accent on "Arctic"

135) Distributions of descents:

a) \(o\) descent on "and"
b) \(x\) descent on "gulls"
c) \(\&\) descent on "in"
d) \(+\) descent on "the"
e) \(\#\) descent on "Arc-"
f) \(\$_\) prior descent of "gulls"

136) Simplified block diagram to generate Fo-by-rule.
137-146) Flow charts for the Algorithm.
147) Illustration of the operation of the Algorithm.
148) Comparison of predicted with actual contours.

SENTENCE

Operators
(quantifiers
and
qualifiers)

Nucleus
Verb

(case arguments)

Fig. 1

Fig. 2
Three types of accent:

a) basic primary accent

b) fall primary accent

c) secondary accent

Hierarchy of Fo patterns:

a) utterance level

b) clause/phrase level

c) word level

d) phoneme level

Fig. 3

429
Fig. 8

Fo values

% of words

Fig. 9

Fo rise accents

% of words

$\bar{o} = 114.8$, $SD = 4.0$, $N = 229$

$\bar{x} = 111.1$, $SD = 5.5$, $N = 226$

$\bar{\bar{o}} = 95.1$, $SD = 3.9$, $N = 226$

$\bar{o} = +3.2$, $SD = 4.0$, $N = 87$

$\bar{x} = +6.9$, $SD = 3.6$, $N = 110$

$\bar{\bar{o}} = +16.1$, $SD = 5.1$, $N = 15$

$\bar{t} = +1.1$, $SD = 1.7$, $N = 9$

$\bar{x} = +4.5$, $SD = 5.1$, $N = 8$

$\bar{\bar{o}} = +17.3$, $SD = 4.1$, $N = 229$
Fig. 10a

% of words

Fo descents

\( \bar{o} = -23.9, \ SD = 7.3, \ N = 87 \)
\( \bar{x} = -18.1, \ SD = 6.5, \ N = 110 \)
\( \bar{s} = -19.7, \ SD = 7.7, \ N = 101 \)
\( \bar{a} = -21.7, \ SD = 7.1, \ N = 96 \)

Fig. 10b

% of words

Fo descents

\( \bar{a} = -29.6, \ SD = 4.7, \ N = 15 \)
\( \bar{f} = -28.7, \ SD = 5.1, \ N = 9 \)
\( \bar{k} = -23.0, \ SD = 3.6, \ N = 8 \)
Fig. 11
% of words
- $\bar{\sigma} = -9.3$, SD = 5.4, N = 88
- $\bar{x} = -10.4$, SD = 5.1, N = 109

Fig. 12
% of words
- $\bar{\sigma} = -1.9$, SD = 2.9, N = 194
- $\bar{x} = -3.8$, SD = 2.9, N = 32

Fig. 13
% of words
- $\bar{\sigma} = -8.9$, SD = 3.4, N = 15
- $\bar{x} = -9.3$, SD = 3.1, N = 15
Fig. 14

"JOE (\{"LL","S"\})" vs. "STUD - \{Y, IED\}"

Fig. 15

Joe's stud ied his books.

Joe stud ied his books.
Joe has studied his books.  

Joe might study his books.  

Joe will study his books.  

Joe does study his books.  

Fig. 18
Fig. 21

Joe has been studying his books.

Joe has not studied his books.

Joe does not study his books.

Fig. 22
Joe might not study his books.

Joe might have studied his books.

Joe might not study his books.

Joe might have studied his books.

Joe doesn't study his books.

Joe might've studied his books.

Fig. 23

Fig. 24
Joe might not have studied his books.

...Joe might not have studied his books...

...Joe might not have studied his books...

Fig. 27

Fig. 28
Fig. 29a

Fig. 29b

Hz

160

140

120

100

80

QUANT  "BOYS"  "MIGHT"  ("NOT")  ("HAVE")  "STUD - IED"

0  400  800  1200 msec

160

140

120

100

80

QUANT  "BOYS"  "MIGHT"  ("NOT")  "HAVE"  "STUD - IED"

0  400  800  1200 msec
Some boys might study their books. No boys might study their books.

Both boys might not have studied their books. Both boys might not have studied their books.

Joséphine might have studied her books. Is Joséphine might have studied her books...
Fig. 42

"JOE" "MIGHT" ADVERB ("NOT") AUX "STUDIED"

Fig. 43

Joe might then have studied his books.

Joe might perhaps not have studied his books.
Fig. 44

"JOE" "MIGHT" ("NOT") "HAVE" ADVERB "STUDIED"

Fig. 45

"JOE" "MIGHT" ("NOT") "HAVE" ADVERB "STUDIED"

Fig. 45

Joe might have acted daily studied his books.
Fig. 49
The steel factory might polarize the town.

Many factors might polarize the town.

The boys in the dorm might have actually...

The boys in the dorm across the river might have...

Fig. 50

Fig. 51
A farmer was eating the carrot.

(...) = old information

(The farmer was) eating (the carrot).

(The farmer was) eating the carrot.

(The farmer was eating) the carrot.
A farmer was eating the carrot.

The farmer (was eating) the carrot.

(The farmer was) eating (the carrot).

(The farmer was) eating the carrot.

(The farmer was eating) the carrot.

Fig. 54 (KS)
It was the farmer who was eating the carrot.

It was a farmer (who was eating a carrot).

It was the farmer who was eating the carrot.

It was a farmer (who was eating a carrot).

It was the farmer who was eating the carrot.

It was a farmer (who was eating a carrot).

Fig. 55
He bought a red car and a blue car.

He bought a red car, a blue car,...

He bought a red car and a red blouse.

He bought a red car and a blue one...

...and a blue coat.

Fig. 58
He bought a red car and a blue car.

He bought a red car, a blue car, ...

He bought a red car and a red blouse.

He bought a red car and a blue one.

... and a blue coat.

Figs. 59-60 (KS)
..(Joe) boiled the noodles he'd bought.

..(Joe) boiled (the noodles) he'd bought.

Fig. 62
Joe went to the library with his medical books.

Fig. 63

paragraph

Joe studied the medical books.

Fig. 64

paragraph

Joe studied the medical books.

Fig. 65
Joe brought his medical books,... they studied the medical books.

Fig. 66

Fig. 67

Fig. 68
If the painter does not use a plastic brush, ....

If the painter does not use a bristle brush, ...

Fig. 69

Fig. 70
Joseph had welcomed Susan.

Nicky has never eaten fish.

Joseph was welcomed by Susan.

Never has Nicky eaten fish.

Fig. 71

Fig. 72
A farmer was the one eating the carrot.

What the farmer was doing was eating a carrot.

Fig. 75

A farmer was the one eating the carrot.

What the farmer was doing was eating a carrot.

Fig. 76

A farmer was the one eating the carrot.

What the farmer was doing was eating a carrot.

Fig. 77
Fig. 78

Fig. 79
A cow was eating the carrot.

It was a cow that was eating a carrot.

A cow was eating the carrot.

It was a cow that was eating a carrot.

A cow was eating the carrot.

It was a cow that was eating a carrot.

Fig. 80

Fig. 81
A gazelle was eating the carrot.

It was a gazelle that was eating the carrot.

A gazelle was the one who was eating the carrot.

There was a gazelle eating the carrot.

Fig. 82

Fig. 83
Joe delivered the meat to the market.

It was Joe who delivered the meat to the market.

It was the meat that Joe delivered to the market.

It was to the market that Joe delivered the meat.

Joe delivered the meat to the market.

It was Joe who delivered the meat to the market.

Fig. 84

Fig. 85
Fig. 88

('THERE'S') 'SOMETHING' ('THAT') 'KEEPS'

'STEALING' 'THE' 'BAIT'

Fig. 89

('IT WAS') 'BECAUSE' 'JOE' 'BOUGHT' 'A' 'NEW' 'CAR' ('THAT') 'WE' 'WENT' 'FOR' 'A' 'RIDE'
"IT'S TRUE") "THAT" "FISH" "IS" "TAS - TY" ("IS "TRUE")

Fig. 94

Fig. 95
Fig. 96

That Fred won the race surprised me.

Fred won the race, which surprised me.

Figs. 97-98
Fig. 99

Have the boys been studying their books?

Fig. 100

Have n't the boys been studying their books?
Fig. 101
Are you ready?

Fig. 102
Did you hear a horse whinny?
Did you hear a horse, Winnie?

Fig. 103
Are these red pencils?
Are these red pencils yours?
Are these red pencils yours or mine?

When I speak German, do you understand me?

Do you understand me, when I speak German?
"Which" "books" 
\{aux ("n't")\} \{"Joe" "the-boys" ("not") \} aux "stud - ying" ??

What's for dinner, Stan?

What's for dinner -- steak?

Fig. 106

Fig. 107
The good flies quickly passed.

He speaks English naturally.

(i.e., of course)

He speaks English, naturally.

Fig. 108

Fig. 109
It's the baker, Mister Jones.

John has a brother, Robert.
Bears live in the Arctic. Fig. 114

The bears live on the ice with the gulls in the winter. 182

The bears in the Arctic eat lemmings. Fig. 115

The big bears hunt and kill. 179

Bears, gulls, and foxes live in the Arctic. Fig. 116

The Arctic foxes have small square ears.
The large pure white polar bears live...

The small yellowish polar bears live on...

The bears eat lemmings and other animals.

The bears eat lemmings and many other small animals.

Fig. 117

Fig. 118
Fig. 119

This flound-er, it should be cooked care-fully.

Fig. 120

This flound-er should be cooked care-fully.

Fig. 121

This flound-er should be cooked care-fully.
You should care-fully cook the flounder.

You should care-fully cook it, the flounder.

Fig. 122

Fig. 123

Fig. 124
Joe ran the race, like Bob ran his lawn-mower.

John studied Mary, and Bill studied Jane.

Figs. 126-127
"ROBERT" HAS-N'T "BOUGHT" "THE" "CAR" "YET", "BUT" "HE" "WILL" "BUY IT" "LATER" "TODAY"

... but he will buy it later today.

... but he will later today.

Fig. 128

Fig. 129
He tripped over, and sat down on, the stool.

John hit, and Alice caught, the baseball.

Joe walked into and through the sand.

He totally baffles and utterly amazes me.

Fig. 130
Time variation in the sub-contour:

- a) basic
- b) variation
- c) overshoot

Variations with different numbers of sub-contours:

- a) 1 SC
- b) 2 SCs
- c) three SCs

Fig. 131
Fig. 132
\[
\bar{\sigma} = 172.1, \ SD = 8.1, \ N = 22 \\
\bar{x} = 130.7, \ SD = 6.5 \\
\bar{\delta} = 119.1, \ SD = 6.5
\]

**Fig. 133**

\[
\bar{\sigma} = +7.7, \ SD = 3.5, \ N = 22 \\
\bar{x} = +15.4, \ SD = 3.8 \\
\bar{\&} = +4.5, \ SD = 3.6
\]

**Fig. 134**
Fig. 135a

- $\bar{x} = -27.0$, $SD = 11.0$, $N = 22$
- $\bar{s} = -28.0$, $SD = 6.0$
- $\bar{y} = -17.8$, $SD = 8.9$

% of words

Fo descents

Fig. 135b

- $\bar{o} = -14.0$, $SD = 7.6$, $N = 22$
- $\bar{\&} = -0.4$, $SD = 3.3$
- $\bar{+} = -9.9$, $SD = 2.4$
Fig. 136

Fig. 137: Assign Tunes at the Sentence Level:

- **Tag question?**
  - yes: A+B
  - no: A

- **Question**
  - **Wh-**
    - yes/no
  - **Example?**
    - yes: A+B
    - no: A
  - **Alternative?**
    - yes: B+A
    - no: }

- **End in a vocative?**
  - yes
  - no: 0 (0 = no action)

- **Which Tune?**
  - A
  - B

- **Delete end Tune**
  - 0
Fig. 139: At Word Level: Revise accent numbers:

1. **syntactic transformation?**
   - Yes
   - No
     - multisyllabic?
       - Yes
         - +2
       - No
         - 0
     - second in compound?
       - Yes
         - 0
       - No
         - 0

2. **repetition?**
   - Yes
     - successive?
       - Yes
         - 0
       - No
         - 0
     - No
       - 0
         - in same clause?
           - Yes
             - -2 on both
           - No
             - -3 on second

3. **paragraph?**
   - Yes
     - initial content word in sentence?
       - Yes
         - -3
       - No
         - 0
     - third or later occurrence?
       - Yes
         - -1
       - No
         - 0
     - which sentence?
       - 1-2
         - 0
       - 3-5
         - -1
       - 6-up
         - -2

4. **parallel structure?**
   - Yes
     - parallel words?
       - Yes
         - -1
       - No
         - 0
   - No
     - final one?
       - Yes
         - +1
       - No
         - +2

5. **contrastive stress?**
   - Yes
     - stressed words?
       - Yes
         - 0
       - No
         - 0
   - No
     - 0
     - -2
Fig. 140: Peak values on ASs:

Assign initial (head) peak:

let \( x \) = number of clauses and \( y \) = number of phrases:

head peak = minimum \( 185, (123-8x) + (12-2x) * y \)

\( \text{Fo room} = \text{head peak} - z \):

- \( A \):
  - \( z = 110 \)

- \( B \):
  - \( z = 125 \)

peak differentials = \( \frac{\text{room}}{\# \text{ of content words}} \)

which peak?

<table>
<thead>
<tr>
<th></th>
<th>first</th>
<th>next to last</th>
<th>other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+15%</td>
<td>+15%</td>
<td>-15%</td>
</tr>
</tbody>
</table>

Adjust peaks:

NP level?

<table>
<thead>
<tr>
<th></th>
<th>+1</th>
<th>0</th>
<th>-1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+40%</td>
<td>0%</td>
<td>-40%</td>
</tr>
</tbody>
</table>

accent number =

accent number + 10% *

(accent number - 8) *

local Fo room

Fig. 141: Accents:

rise accent or fall accent?

rise

fall

head content word?

yes

no

yes

no

(peak - 110) (40% * room * (1 + 20% * break number))
Fig. 142: Modifications to ASs:

- **number of USs between 2 ASs?**
  - 0
  - 2
  - 3-up

- -40% for both rise accents
- -20% for first peak
- +20% for second peak
- peak - 105 for 2nd accent
- +15% for both accents
- +10% for first peak
- -15% for second peak
- +15% for first peak
- -25% for second peak

- adjust end-points

- **3 ASs in a row?**
  - yes
  - reverse accents
  - no

- **4 or more?**
  - yes
  - -30% for first accent
  - no
  - -25% for first accent

- **Tune on AS?**
  - A
  - B
  - no

- fall accent = peak - 85

- add a rise

- **Tune in clause?**
  - A
  - B
  - 0

- shift 80% of fall to rise accent

Fig. 143: Assign CRs:

- CR value = CR number * 8 Hz

- **type?**
  - fall + rise
  - monotonic

- +30% on fall accent
- -80% on fall accent
Fig. 144: USs:

for each AS, start-point = peak - rise accent
end-point = peak - fall accent

US drop-off = (end-point of one AS) - (start-point of next AS)

<table>
<thead>
<tr>
<th>negative drop-off?</th>
<th>US with Tune?</th>
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</thead>
<tbody>
<tr>
<td>yes</td>
<td>A</td>
</tr>
<tr>
<td>no</td>
<td>B</td>
</tr>
</tbody>
</table>

+20% increase on peak and accents

Assign ratio of (fall:drop):

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<th>AS non-final in word?</th>
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<tbody>
<tr>
<td>yes</td>
</tr>
<tr>
<td>no</td>
</tr>
</tbody>
</table>

end with voiced consonant?

<table>
<thead>
<tr>
<th>1:1</th>
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</thead>
<tbody>
<tr>
<td>yes</td>
</tr>
<tr>
<td>no</td>
</tr>
</tbody>
</table>

Ratio of (drop:fall) in US is 1:1

Fig. 145: Phonetic Division:

Assign ratio of (prior jump:rise):

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<th>voiced AS start?</th>
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<tbody>
<tr>
<td>yes</td>
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<tr>
<td>no</td>
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</table>

80%:20% 20%:80%

Fig. 146:

initial AS in P-unit?

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<td>yes</td>
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<td>no</td>
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</tbody>
</table>

AS word-final?

<table>
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<tr>
<th>overshoot with 20% of accent</th>
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<tbody>
<tr>
<td>yes</td>
</tr>
<tr>
<td>no</td>
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</tbody>
</table>

100% 60% for 1st 45% for 1st
40% for 2nd 35% for 2nd
20% for 3rd 0% for rest
<table>
<thead>
<tr>
<th>Jo-seph</th>
<th>bas-i-cally</th>
<th>is</th>
<th>a</th>
<th>good</th>
<th>man.</th>
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<th>actions</th>
<th>rule</th>
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Illustration of operation of algorithm

Fig. 147a
<table>
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<tr>
<th>With no</th>
<th>job</th>
<th>would</th>
<th>Joe</th>
<th>be</th>
<th>hap - py.</th>
<th>comments</th>
<th>actions</th>
<th>rule</th>
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<tr>
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Fig. 147c
Predicted versus actual spoken Fo contours:

The actual plot is similar to those above, with selected peak values shown. The predicted plot is aligned with the actual durations, and is illustrated by dotted lines.

Fig. 148a
With no job would Joe be happy.

Fig. 148b

Not many people have nowhere to live.

Fig. 148c
Table Legends:

Underlined words here indicate word-classes from which different words were chosen. Parentheses indicate optional elements; words separated by semi-colons indicate disjunctive choice. See 3.2.2 for a description of the tables.

Table 1: #1: Joe studied his books.
    #2: Joe'll study his books; Joe's studied his books.

Table 2: #1: Joe (aux; class B modal) (study; studied; studying) his books.
    #2: Joe (does; did) study his books.
    #3: Joe class A modal study his books.
    #4: Joe (can't; won't) study his books.
    #5: Joe was studying his books. (paragraph sentence #1)
    #6: Joe should study his books. (paragraph sentence #10)

Table 3: #1: Joe has been studying his books.
    #2: Joe (aux; class B modal) not (study; studied; studying) his books.
    #3: Joe class A modal not study his books.
    #4: Joe accented bisyllabic negative contraction (studied; studying) his books.
    #5: Joe 'bisyllabic negative contraction' (studied; studying) his books.
    #6: Joe accented class A modal. aux (studied; studying) his books.

Table 4: #1: Joe has not been studying his books.
    #2: Joe class A modal, not aux (studied; studying) his books.
    #3: Joe class A modal have been studying his books.
    #4: Joe hasn't been studying his books.
    #5: Joe might not have been studying his books.
    #6: Joe class A modal not aux (studied; studying) his books.
    #7: ... Joe may have been studying his books ... (paragraph sentence #3)
    #8: ... Joe might not have studied his books. (paragraph sentence #9)
    #9: Same

Table 5: #1: Quantifier boys might study their books.
    #2: Quantifier boys might have studied their books.
    #3: Quantifier boys might not have studied their books.
    #4: Quantifier boys might not have studied their books.
    #5: ... some boys might study their books. (paragraph sentence #11)
    #6: ... many boys might study their books ... (paragraph sentence #7)
    #7: ... all the boys might have studied their books. (paragraph sentence #5)
    #8: ... some boys might not have studied their books ... (paragraph sentence #6)
Table 6: see Table 87.

Table 7: see Table 96.

Table 8: #1: Joe adverb might have studied his books.
#2: Joe adverb might not have studied his books. (accent on "not")
#3: Joe adverb might not have studied his books. (accent on "might")

Table 9: #1: Joe might adverb have studied his books.
#2: Joe might adverb not have studied his books.

Table 10: #1: Joe might have adverb studied his books.
#2: Joe might not have adverb studied his books. (accent on "not")
#3: Joe might not have adverb studied his books. (accent on "might")
#4: Joe might have even studied his books . . . (paragraph sentence #12)

Table 11: #1: Joe might have studied his books.
#2: Joseph might have studied his books.
#3: Josephine might have studied her books.
#4: Joe might not have studied his books.
#5: Joseph might not have studied his books.
#6: Josephine might not have studied her books.
#7: . . . Josephine might have studied her books . . . (paragraph sentence #8)

Table 12: #1: Joe might have read the statement.
#2: Joe might have recorded the statement.
#3: Joe might have recognized the statement.
#4: Joe might have recollected the statement.
#5: Joe might not have read the statement.
#6: Joe might not have recorded the statement.
#7: Joe might not have recognized the statement.
#8: Joe might not have recollected the statement.

Table 13: #1: The boys have studied their books.
#2: The boys might study their books.
#3: The boys all studied their books.
#4: The boys have all studied their books.
#5: The boys might all study their books.
#6: The boys all have studied their books.
#7: The boys all might study their books.

Table 14: #1: Joseph might have studied these books.
#2: Joseph might have studied all the books.
#3: Joseph might have studied both books.
#4: Joseph might have studied many books.
#5: Joseph might have studied some books.
#6: Joseph might not have studied his books.
#7: Joseph might not have studied these books.
#8: Joseph might not have studied all the books.
#9: Joseph might not have studied both books.
#10: Joseph might not have studied many books.
#11: Joseph might not have studied any books.

Table 15: #1: Joseph might have studied.
#2: Joseph might (actually; occasionally) have studied.
#3: Joseph might have (actually; simply) studied his books.
#4: Joseph might have (quickly; rapidly) studied his books.
#5: Joseph might have studied his books (all night; quietly).
#6: Joseph might have actually studied his books (all night; quietly).
#7: Joseph (will; would) have studied his books.
#8: Joseph (will; would) not have studied his books.
#9: Joseph would have (then; perhaps; actually) studied his books.
#10: Joseph would not have (then; perhaps, actually) studied his books.

Table 16: #1: Some boys might have studied their books.
#2: (Some; Many) boys might have actually studied their books.
#3: Many boys might have then studied their books.
#4: (Some; Many) boys might have perhaps studied their books.
#5: (Some; Many) boys would have actually studied their books.
#6: Some boys would have then studied their books.
#7: (Some; Many) boys would have perhaps studied their books.
#8: (Some; Many) boys might not have actually studied their books.
#9: (Some; Many) boys might not have then studied their books.
#10: (Some; Many) boys might not have perhaps studied their books.
#11: (Some; Many) boys would not have actually studied their books.
#12: (Some; Many) boys would not have then studied their books.
#13: (Some; Many) boys would not have perhaps studied their books.

Table 17: #1: The cold facts might polarize the town.
#2: The cold facts might be polarizing the town.
#3: The cold facts might have been polarizing the town.
#4: Many factors might polarize the town.
#5: Many factors might be polarizing the town.
#6: Many factors might have been polarizing the town.
#7: The steel factory might polarize the town.
#8: The steel factory might be polarizing the town.
#9: The steel factory might have been polarizing the town.

Table 18: #1: The boys might have studied their books.
#2: The boys might have studied their Psychology books.
#3: The boys might have occasionally studied their books.
#4: The boys might have (occasionally; actually) studied their Psychology books.
#5: The boys in the (dorm; dormitory; library; classroom) might have studied their books.
Table 19:  #1: The boys in the (dorm; dormitory; classroom; library) might have studied their books.
#2: The boys in the dorm might have (occasionally; actually) studied their books.
#3: The boys in the dorm across the river might have studied their books.
#4: The boys in the dorm across the river might have (occasionally; actually) studied their Psychology books.

Table 20:  #1: The farmer was eating the carrot.
#2: Who was eating the carrot? The farmer was eating the carrot.
#3: What was the farmer doing with the carrot? The farmer was eating the carrot.
#4: What was the farmer eating? The farmer was eating the carrot.
#5: What was the farmer doing? The farmer was eating the carrot.
#6: It was the farmer who was eating the carrot.
#7: Who was that? It was a farmer who was eating a carrot.
#8: Who was eating a carrot? It was a farmer who was eating a carrot.

Table 21:  #1: He bought a red car and a red blouse.
#2: He bought a red car and a blue car.
#3: He bought a red car and a blue one.
#4: He bought a red car, a blue car, and a blue coat.

Table 22:  #1: Joe went to the store to buy some (food; noodles). (citation)
#2: same (paragraphs #1 & 6, first sentence of 2)

Table 23:  #1: Jane was studying her history books yesterday. (citation)
#2: same (paragraph #2, first sentence of 4)

Table 24:  #1: House painting is an easy task if done properly. (citation)
#2: same (paragraph #3, first sentence of 6)

Table 25:  #1: Joe went to the library with his medical books. (citation)
#2 same (paragraph #4, first sentence of 2)
Table 26: #1: Joe and Sue were going to the library. (citation)
    #2: same (paragraph #7, first sentence of 3)

Table 27: #1: Susan and Robert decided to remodel the living room in their house.
    #2: same (paragraph #5, first sentence of 6)

Table 28: #1: When he got home, Joe boiled the noodles he'd bought. (citation)
    #2: same (paragraph #1, last sentence of 2)
    #3: same (paragraph #6, last sentence of 2)

Table 29: #1: When he arrived at the library, Joe studied the medical books. (citation)
    #2: same (paragraph #4, last sentence of 2)

Table 30: #1: Joe brought his medical books, and Sue carried her biology books. (citation)
    #2: same (paragraph #7, second sentence of 3)

Table 31: #1: When they arrived at the library, they studied the medical books. (citation)
    #2: same (paragraph #7, last sentence of 3)

Table 32: #1: While studying her books, Jane heard her room-mate returning from the store. (citation)
    #2: same (paragraph #2, second sentence of 4)

Table 33: #1: Mary had bought some books at the store, and showed the books to Jane. (citation)
    #2: same (paragraph #2, third sentence of 4)

Table 34: #1: Jane looked at the books, and said that they were cheaper than her history books. (citation)
    #2: same (paragraph #2, last sentence of 4)

Table 35: #1: Susan moved the sofa, and then rolled up the carpet in the living room. (citation)
    #2: same (paragraph #5, second sentence of 6)

Table 36: #1: Robert carried the carpet out to the porch, and placed it next to the sofa. (citation)
    #2: same (paragraph #5, third sentence of 6)

Table 37: #1: Susan had earlier covered the sofa with a cloth, and now laid some of the lamps on it. (citation)
    #2: same (paragraph #5, fourth sentence of 6)
Table 38: #1: Susan then tripped over the carpet, and asked Robert to move the carpet off the porch. (citation)
   #2: same (paragraph #5, fifth sentence of 6)

Table 39: #1: Carrying out some more rugs, Robert agreed with Susan that the porch was too crowded, and so he removed the carpet. (citation)
   #2: same (paragraph #5, last sentence of 6)

Table 41: #1: If the painter does not use a bristle brush to apply the first coat of paint, the paint may flake and peel upon drying. (citation)
   #2: same (paragraph #3, third sentence of 6)

Table 40: #1: The painter should use bristle brushes and an oil paint. (citation)
   #2: same (paragraph #3, second sentence of 6)

Table 42: #1: When using oil paint, one should have a dry, clean surface to start with. (citation)
   #2: same (paragraph #3, fourth sentence of 6)

Table 43: #1: If the surface is dirty, a coat of paint will not last long after drying. (citation)
   #2: same (paragraph #3, fifth sentence of 6)

Table 44: #1: After use, the paint brushes must be cleaned before being allowed to dry. (citation)
   #2: same (paragraph #3, last sentence of 6)

Table 45: #1: Richard himself prepared the casserole.
   #2: Richard prepared himself the casserole.
   #3: Richard prepared the casserole himself.

Table 46: #1: The table was as long as the sofa.
   #2: The table was as long as the sofa was.
   #3: The table was as long as the sofa was wide.

Table 47: #1: Fred bought more lobster than Joe sold. (accent on "bought")
   #2: Same (accent on "more")
   #3: Fred bought more lobster than Joe sold bluefish.

Table 48: #1: She slapped him in the face, and then she hit the bastard. (accent on "hit")
   #2: Same (accent on "bastard")

Table 49: #1: Tomorrow he and I will drive home.
   #2: He and I will drive home tomorrow.
Table 50:  #1: Who did what to whom?  
    #2: Who attacked with force?

Table 51:  #1: Joe will never actually eat fish again.  
    #2: Joe will never, never eat fish again.

Table 52:  #1: The seeds were sown by the farmer's son.  
    #2: Same (but in paragraph)  
    #3: The seeds were sown by the riverside.

Table 53:  #1: Joe was seldom driven by the chauffer.  
    #2: Same (but in paragraph)  
    #3: Joe was seldom driven by the sheep farm.

Table 54:  #1: The church bells had already been rung by some boys.  
    #2: Same (but in paragraph)  
    #3: The church bells had already been rung by sunset.

Table 55:  #1: The mile race was always run by the boys.  
    #2: The mile race was always run by the book.

Table 56:  #1: The race was actually won by a horse.  
    #2: The race was actually won by a nose.  
    #3: Same (but in paragraph)

Table 57:  #1: The merchandise was stolen by Fred.  
    #2: The merchandise was stolen by fraud.

Table 58:  #1: The research was done by Neal.  
    #2: The research was done by night.

Table 59:  #1: He had earlier boiled some water for a while.  
    #2: He had earlier boiled some water for his coffee.  
    #3: Same (but in paragraph)

Table 60:  #1: The 2 sides fought a war over the years.  
    #2: The 2 sides fought a war over the bridge.

Table 61:  #1: He quickly ate the small meal on his way.  
    #2: Same (but in paragraph)  
    #3: He quickly ate the small meal on his plate.

Table 62:  #1: We beat the team with great effort.  
    #2: We beat the team with gray helmets.

Table 63:  #1: He drank his coffee without thinking.  
    #2: Same (but in paragraph)  
    #3: He drank his coffee without sugar.
Table 64: | #1: He found the way through chance.  
| #2: He found the way through town.  
| #3: Same (but in paragraph)

Table 65: | #1: Joseph had welcomed Susan.  
| #2: Joseph was welcomed by Susan.

Table 66: | #1: Nicky has never eaten fish.  
| #2: Never has Nicky eaten fish.

Table 67: | #1: Cooking the fish will be the most fun.  
| #2: Cooking the fish will be the master chef.

Table 68: | #1: George plans to buy some juice, and he will buy some.  
| #2: George plans to buy some juice, and buy some he will.

Table 69: | #1: A farmer was eating the carrot.  
| #2: It was a farmer (who was) eating the carrot.  
| #3: There was a farmer eating the carrot.  
| #4: This was the farmer who was eating a carrot.  
| #5: A farmer was the one (who was) eating the carrot.  
| #6: A farmer was the one eating the carrot.  
| #7: What the farmer was doing was eating a carrot.  
| #8: A cow was eating the carrot.  
| #9: It was a cow that was eating the carrot; There was a cow eating the carrot.  
| #10: A cow was the one who was eating the carrot.  
| #11: A gazelle was eating the carrot.  
| #12: It was a gazelle that was eating the carrot; There was a gazelle eating the carrot.  
| #13: A gazelle was the one who was eating the carrot.

Table 70: | #1: Joe delivered the meat to the market.  
| #2: It was Joe who delivered the meat to the market.  
| #3: It was the meat that Joe delivered to the market.  
| #4: It was the market that Joe delivered the meat to.  
| #5: It was to the market that Joe delivered the meat.  
| #6: To the market Joe delivered the meat.

Table 71: | #1: Eating the carrot was a farmer.  
| #2: The one (who was) eating the carrot was a farmer.  
| #3: It was eating a carrot that the farmer was doing; Eating a carrot is what the farmer was doing.

Table 72: | #1: A carrot was eaten by the farmer.  
| #2: There was a carrot eaten by the farmer; It was a carrot (that was) eaten by the farmer.  
| #3: It was a carrot eaten by the farmer.
Table 73: #1: The thing eaten by the farmer was a carrot.

Table 74: #1: Something keeps stealing the bait.
    #2: There's something that keeps stealing the bait.

Table 75: #1: Because Joe bought a new car, we went for a ride.
    #2: It was because Joe bought a new car that we went for a ride.

Table 76: #1: Joe said the house had termites, before he walked out.
    #2: Joe said, "the house has termites," before he walked out.

Table 77: #1: Then Susan, who is Joe's sister, ran out of the house.
    #2: Then Susan (who is Joe's sister) ran out of the house. (parentheses used here)

Table 78: #1: Bruce said that Joseph (might have; might not have; had; had not) (actually) studied his books.
    #2: Bruce might have said that Joseph had (not) (actually) studied his books.
    #3: Bruce might not have said that Joseph had (actually) studied his books.
    #4: Bruce actually said that Joseph (might (not) have; had (not)) studied his books.
    #5: Bruce might have actually said that Joseph had (not) studied his books.
    #6: Bruce might not have actually said that Joseph had studied his books.

Table 79: #1: Bruce (might (not) have) (actually) said that Joseph had studied his books.
    #2: Bruce (actually) said that Joseph might have studied his books.
    #3: Bruce (might have) (actually) said that Joseph had not studied his books.
    #4: Bruce (might (not) have) said that Joseph had actually studied his books.
    #5: Bruce (actually) said that Joseph might not have studied his books.
    #6: Bruce said that Joseph might have actually studied his books.
    #7: Bruce (might have) said that Joseph had not actually studied his books.
    #8: Bruce said that Joseph might not have actually studied his books.

Table 80: #1: What Bruce said was that Joseph might not have actually studied his books.
    #2: What Bruce said was actually that Joseph might not have studied his books.
    #3: What Bruce said might have been that Joseph had not actually studied his books.
    #4: What Bruce said might have actually been that Joseph had not studied his books.
Table 81:  #1: What Bruce might have said was that Joseph had not actually studied his books.
#2: What Bruce might have said was actually that Joseph had not studied his books.
#3: What Bruce might have actually said was that Joseph had not studied his books.

Table 82:  #1: What Bruce actually said was that Joseph might not have studied his books.
#2: What Bruce actually said might have been that Joseph had not studied his books.

Table 83:  #1: Bruce recognized that Joseph might have actually studied his books.
#2: Bruce feared that Joseph might have actually studied his books.
#3: Bruce said that Joseph might have (actually; occasionally) studied his books.
#4: Bruce said that Joseph might have perhaps studied his books.
#5: It is likely that Joseph might have studied his books.
#6: It is likely that Joseph might have actually studied his books.
#7: That Joseph might have studied his books annoyed Susan.
#8: That Joseph might have actually studied his books annoyed Susan.
#9: The thought that Joseph might have studied his books annoyed Susan.
#10: The thought that Joseph might have actually studied his books annoyed Susan.

Table 84:  #1: That fish is tasty.
#2: That fish is tasty is true.
#3: It's true that fish is tasty.

Table 85:  #1: Fred won the race, which surprised me.
#2: That Fred won the race surprised me.

Table 86:  #1: The older woman, who had been flown to the country, is driving to the city; The older woman, who is driving to the city, had been flown to the country; The water, which was boiling on the stove, will be frozen for 3 hours; The water, which will be frozen for 3 hours, was boiling on the stove.
#2: The older woman that had been flown to the country is driving to the city; The older woman that is driving to the city had been flown to the country; The water that was boiling on the stove will be frozen for 3 hours; The water that will be frozen for 3 hours was boiling on the stove.
#3: The older woman, driven to the city, could have been flying to the country; The older woman, flown to the country, could have been driving to the city; The water, boiled for 7 days, was frozen for 3 hours; The water, frozen for 3 hours, was boiled on the stove.
#4: The older woman, driving to the city, could have flown to the country; The older woman, flying to the country, could have driven to the city; The water, boiling on the stove, had been frozen for 3 hours; The water, freezing for 3 hours, had been boiled on the stove.
#5: The older woman, to be driven to the city, has been flown to the country; The older woman, to be flown to the country, has been driven to the city; The water, to be boiled on the stove, was freezing for 3 hours; The water, to be frozen for 3 hours, was boiling on the stove.
#6: The older woman, whose son was flown to the country, has driven to the city.

Table 87: #1: Has Joe been studying his books?; Have the boys been studying their books?
#2: Hasn't Joe been studying his books?; Haven't the boys been studying their books?
#3: Might Joe have been studying his books?; Might the boys have been studying their books?
#4: . . . "Has Joe been studying his books?" (paragraph sentence #2)
#5: " Might the boys have been studying their books?" . . . (paragraph sentence #4)

Table 88: #1: Would a small amount of wood be sufficient?
#2: Would a small amount of paper be sufficient?
#3: Would a small amount of carpeting be sufficient?
#4: Would a small amount of delay be sufficient?
#5: Would a small amount of preparation be sufficient?

Table 89: #1: Seriously, does William intend to resign his job?
#5: Does William seriously intend to resign his job?
#9: Does William intend seriously to resign his job?
#13: Does William intend to resign his job seriously?
#2-4, 6-8, 10-12, 14-16: Same as above (but at faster rates)

Table 90: #1: Could we convene the meeting?
#2: Is there someplace closer that we could convene the meeting?

Table 91: #1: Do you understand me when I speak German?
#2: When I speak German, do you understand me?
#3: Do you get exhausted when you exercise?
#4: Do you get exhausted, when you exercise?
#5: When you exercise, do you get exhausted?

Table 92: #1: Are you ready?
#2: Are you ready, Susan?

Table 93: #1: Did you hear a horse whinny?
#2: Did you hear a horse, Winnie?
Table 94:  #1: Are these red pencils yours or mine?  
           #2: Are these red pencils yours?  
           #3: Are these red pencils?

Table 95:  #1: Do you prefer coffee or soda? or something else?

Table 96:  #1: Which books has Joe been studying?  
           #2: Which books has Joe not been studying?  
           #3: Which books hasn't Joe been studying?  
           #4: Which books might (Joe; the boys) have been studying?

Table 97:  #1: Joe went to what bakery?

Table 98:  #1: What's for dinner, Stan?  
           #2: What's for dinner - steak?

Table 99:  #1: The good flies quickly passed.  
           #2: The good flies quickly past.

Table 100: #1: The maiden countered her enemy.  
            #2: The maid encountered her enemy.  
            #3: The golden closure was pretty.  
            #4: The gold enclosure was pretty.  
            #5: The chicken circled the barn.  
            #6: The chick encircled the barn.

Table 101: #1: She gave the boy plants to water.  
            #2: She gave the bean plants to charity.

Table 102: #1: Earl struck the man on the leg with his fist.  
            #2: Earl struck the man on the leg with the scar.  
            #3: Earl struck the man on the deck with his fist.  
            #4: Earl struck the man on the deck with the scar.

Table 103: #1: Steve or Sam and Joe will be coming. (Steve or Sam)  
            #2: Same (but with "Sam and Joe" grouped)

Table 104: #1: If I'm still around, when you hear from him let me know.  
            #2: If I'm still around when you hear from him, let me know.

Table 105: #1: He speaks English, naturally.  
            #2: He speaks English naturally.  
            #3: Same as #1

Table 106: #1: Only John cooked the fish.  
            #2: Even John cooked the fish.  
            #3: John (also; only) cooked the fish. (adverb grouped with subject)  
            #4: John even cooked the fish. (adverb grouped with subject)  
            #5: John (also; only) cooked the fish. (adverb grouped with verb)
#6: John even cooked the fish. (adverb grouped with verb)
#7: John cooked (also; only) the fish.
#8: John cooked even the fish.
#9: John cooked the fish (also; only).
#10: John cooked the fish even.

Table 107: #1: It's the baker, Mr. Jones. (appositive)
    #2: Same (vocative)
    #3: John has a brother, Robert. (appositive)
    #4: Same (vocative)

Table 108: #1: The 3 people in the house are Joe, my son, and his wife.
    #2: The 2 people in the house are Joe, my son, and his wife.

Table 109: #1: My friend will have to leave immediately.
    #2: You, my friend, will have to leave immediately.

Table 110: #1: The bears in the Arctic live on the ice in the winter; The
    (large pure white; small yellowish) polar bears live on the
    (ice; land).
    #2: Bears and gulls (and foxes (and lemmings)) live in the Arctic;
        (Bears; gulls, and foxes; Bears, gulls, foxes, and lemmings;
        Gulls, foxes, lemmings, and bears; Foxes, lemmings, bears, and
        gulls; Lemmings, bears, gulls, and foxes) live in the Arctic.
    #3: The bears eat lemmings, and other animals dig up berries; The
        bears hunt for lemmings, and dig up berries.
    #4: The bears live (on the ice; with the gulls).
    #5: Bears live in the Arctic.
    #6: The bears live on the ice (with the gulls) in the winter.
    #7: The bears in the Arctic eat lemmings.
    #8: (In the Arctic, the) bears eat lemmings.
    #9: The bears eat lemmings (in the summer; and (many) other (small)
        animals; and other animals dig up berries).
    #10: Thus the large pure white polar bears are said to live on the
        ice . . .
    #11: . . . while the small yellowish polar bears are said to inhabit
        the land.
    #12: The bears live on the ice with the gulls in the winter.
    #13: The bears (in the Arctic) live on the ice (with the gulls) in the
        winter; The bears eat lemmings in the summer.
    #14: In the Arctic, the bears eat lemmings.
    #15: The bears in the Arctic (eat lemmings; live on the ice in the
        winter).

Table 111: #1: The big bears (hunt; kill); The white gulls scavenge.
    #2: The big bears hunt and kill.
    #3: The big bears hunt and kill, and the white gulls and quick foxes
        scavenge. -- first clause.
#4: The big bears are the hunters and killers, the white gulls are the scavengers; The large bears are white, and the small bears are yellowish. -- first clause

#5: Same -- second clause

#6: The quick foxes scavenge.

#7: The Arctic foxes have small square ears.

#8: The Arctic foxes have small square ears, (short sharp muzzles, (narrow little bodies, (and fluffy white fur))).

#9: The white gulls and quick foxes are persistent scavengers.

Table 112: #1: The big white bears hunt.
#2: Same
#3: The shrill white gulls scavenge.
#4: The Arctic foxes have small square ears, (short sharp muzzles, (narrow little bodies, (and fluffy white fur))).
#5-12: Same

Table 113: #1: The small yellowish polar bears live on the land.
#2: The large pure white polar bears live on the ice.
#3: . . . while the small yellowish polar bears are said to inhabit the land.
#4: Thus the large pure white polar bears are said to live on the ice . . .

Table 114: #1: The bears are large and white, . . .
#2: . . . and the foxes are white and quick, . . .
#3: . . . and the gulls are small and shrill.
#4: The big bears hunt and kill.
#5: The big bears hunt and kill, and the white gulls and quick foxes scavenge.
#6: The bears are hunters and killers.
#7: The big bears are the hunters and killers, and the white gulls are the scavengers.
#8: Bears and gulls live in the Arctic.
#9: The gulls and foxes (scavenge; are scavengers).

Table 115: #1: Bears and gulls and foxes live in the Arctic.
#2: Bears, gulls, and foxes live in the Arctic.
#3: Bears and gulls and foxes and lemmings live in the Arctic.
#4: Bears, gulls, foxes, and lemmings live in the Arctic.
#5: The gulls and foxes (scavenge; are scavengers); (Bears and gulls (and foxes (and lemmings)));
Bears, gulls, and foxes; Bears, gulls, foxes, and lemmings; Gulls, foxes, lemmings, and bears; Foxes, lemmings, bears, and gulls; Lemmings, bears, gulls, and foxes) live in the Arctic.
#6-10: Same
Table 116:  #1: The white gulls and quick foxes (scavenge; are persistent scavengers); The big bears hunt and kill, and the white gulls and quick foxes scavenge.  
#2: The bears are clever hunters and dangerous killers.

Table 117:  #1: The bears eat lemmings and other animals.  
#2: The bears eat lemmings and many other small animals.

Table 118:  #1: The bears (eat lemmings, and other animals; hunt for lemmings, and) dig up berries.  
#2: The big bears (hunt and kill; are the hunters and killers), and the white gulls (and quick foxes scavenge; are the scavengers); The bears are large and white, and the foxes are white and quick, and the gulls are small and shrill.  
#3: The large bears are white, and the small bears are yellowish; The bears are large and white, and the foxes are white and quick, and the gulls are small and shrill.  
#4: The Arctic foxes have small square ears, (short sharp muzzles, (narrow little bodies, (and fluffy white fur))).  
#5: The bears are large and white, and the foxes are white and quick, and the gulls are small and shrill; The bears are hunters (and killers); The bears are clever hunters and dangerous killers.  
#6: The large bears are white, and the small bears are yellowish.  
#7: Thus the large pure white polar bears are said to live on the ice, while the small yellowish polar bears are said to inhabit the land; The gulls and foxes are scavengers; The white gulls and quick foxes are scavengers.  
#8: The white gulls and quick foxes (scavenge; are persistent scavengers); The big bears hunt and kill, and the white gulls and quick foxes scavenge.  
#9: The bears are clever hunters and dangerous killers; The Arctic foxes have small square ears, short sharp muzzles, (narrow little bodies, (and fluffy white fur)).  
#10: The big bears are the hunters and killers, and the white gulls are the scavengers.  
#11: The bears (eat lemmings in the summer; live on the ice with the gulls in the winter).  
#12: The bears (in the Arctic) live on the ice (with the gulls) in the winter.

Table 119:  #1: Bears and gulls and foxes (and lemmings) live in the Arctic.  
#2: Bears and gulls live in the Arctic; The gulls and foxes (scavenge; are scavengers).  
#3: (Bears and gulls and foxes (and lemmings); Bears, gulls, and foxes; Bears, gulls, foxes, and lemmings; Gulls, foxes, lemmings, and bears; Foxes, lemmings, bears, and gulls; Lemmings, bears, gulls, and foxes) live in the Arctic; The bears are large and
white, and the foxes are white and quick, and the gulls are small and shrill; The big bears hunt and kill, (and the white gulls and quick foxes scavenge); The bears are hunters and killers; The big bears are the hunters and killers, and the white gulls are the scavengers.

#4: The bears in the Arctic (eat lemmings; live on the ice in the winter).

#5: The bears live on the ice (with the gulls) in the winter.

#6: Bears live in the Arctic.

#7: The bears in the Arctic live on the ice in the winter; (Thus) the large pure white polar bears (are said to) live on the ice; (... while) the small yellowish polar bears (are said to inhabit; live on) the land; (Bears and gulls (and foxes (and lemmings)); Bears, gulls, and foxes; Bears, gulls, foxes, and lemmings; Gulls, foxes, lemmings, and bears; Foxes, lemmings, bears, and gulls; Lemmings, bears, gulls, and foxes) live in the Arctic.

Table 120: #1: The bears are hunters.

#2: The bears are clever hunters and dangerous killers.

#3: The bears are hunters and killers; The big bears are the hunters, and the white gulls are the scavengers.

#4: (In the Arctic, the) bears eat lemmings; The bears in the Arctic eat lemmings.

#5: Bears (and) gulls (and) foxes and lemmings live in the Arctic; The bears eat lemmings (in the summer; and (many) other (small) animals; and other animals dig up berries); The bears hunt for lemmings, and dig up berries.

#6: (Gulls, foxes, lemmings, and bears; Foxes, lemmings, bears, and gulls; Lemmings, bears, gulls, and foxes) live in the Arctic.

#7: (Bears (and gulls (and foxes (and lemmings)))); Bears, gulls, and foxes; Bears, gulls, foxes, and lemmings; Gulls, foxes, lemmings, and bears; Foxes, lemmings, bears, and gulls; Lemmings, bears, gulls, and foxes) live in the Arctic.

#8: The bears in the Arctic (eat lemmings; live on the ice in the winter).

#9: The Arctic foxes have small square ears, (short sharp muzzles, (narrow little bodies, (and fluffy white fur))).

#10: The large bears are white, and the small bears are yellowish.

#11: Thus the large pure white polar bears are said to live on the ice, while the small yellowish polar bears are said to inhabit the land.

#12: The small yellowish polar bears live on the land.

#13: The gulls and foxes (scavenge; are scavengers); The quick foxes scavenge; The white gulls and quick foxes (scavenge; are persistent scavengers); The big bears hunt and kill, and the white gulls and quick foxes scavenge; The Arctic foxes have small square ears; (Lemmings,) bears, gulls, and foxes; Bears and gulls and foxes) live in the Arctic.
The Arctic foxes have small square ears, short sharp muzzles, (narrow little bodies, (and fluffy white fur)).

(Bears (and) gulls (and) foxes and lemmings; Gulls, foxes, lemmings, and bears; Foxes, lemmings, bears, and gulls) live in the Arctic.

The bears are (hunters and killers; clever hunters and dangerous killers).

The big bears are the hunters and killers, and the white gulls are the scavengers.

The Arctic foxes have small square ears and short sharp muzzles.

The Arctic foxes have small square ears, short sharp muzzles, narrow little bodies, (and fluffy white fur).

The Arctic foxes have small square ears, short sharp muzzles, and narrow little bodies.

The Arctic foxes have small square ears, short sharp muzzles, narrow little bodies, and fluffy white fur.

The bears eat lemmings in the summer.

The ((shrill) white) gulls scavenge; The (gulls and foxes; white gulls and) quick foxes scavenge; The big bears hunt and kill, and the white gulls and quick foxes scavenge.

The gulls and foxes are scavengers; The white gulls and quick foxes are persistent scavengers; The big bears are the hunters and killers, and the white gulls are the scavengers.

The bears eat lemmings, and other animals dig up berries; The bears hunt for lemmings, and dig up berries.

The bears (in the Arctic) live on the ice (with the gulls) in the winter.

The bears eat lemmings and (many) other (small) animals.

The white gulls and quick foxes are persistent scavengers.

The Arctic foxes have small square ears, short sharp muzzles, narrow little bodies, (and fluffy white fur).

Same.

The Arctic foxes have small square ears, short sharp muzzles, narrow little bodies, and fluffy white fur.

Thus the large pure white polar bears are said to live on the ice, while the small yellowish polar bears are said to inhabit the land.

Table 121: Monosyllabic accented words:

#1: sentence-initial & voiced
#2: sentence-initial & unvoiced
#3: sentence-initial & ("b""); "dig")
#4: sentence-initial & "Thus"
#5: clause-initial & voiced
#6: clause-initial & unvoiced
#7: clause-initial & "dig"
#8: phrase-initial & voiced
#9: phrase-initial & unvoiced
Table 122: #1: John had a fearless and brave son.
#2: John had a fearful yet brave son.
#3: He respected but feared the people.

Table 123: #1: John and Mary came to the party.
#2: John and not Mary came to the party.
#3: John but not Mary came to the party.

Table 124: #1: The less mentioned, the better for all of us.
#2: The less that is mentioned, the better for all of us.
#3: The more money they have, the less they spend wisely.

Table 125: #1: Mary asked a question of her partner.
#2: Mary asked her partner a question.

Table 126: #1: A nice neighbor has given a few pots to my old friend.
#2: A nice neighbor has given my old friend a few pots.
#3: A nice neighbor has given my old friend with the beard a few pots.
#4: A nice neighbor has given my old friend with the beard a few pots from his kitchen.
#5: A nice neighbor has given my old friend with the beard a few pots from his kitchen in the blue house.

Table 127: #1: Cal gave a rug to Sue.
#2: Cal gave it to Sue.
#3: Cal gave her a rug.
#4: Cal gave Sue a rug.
#5-7: Same (but at faster rates)

Table 128: #1: The bears hunt for lemmings, and dig up berries; The big bears (hunt and kill; are the hunters and killers), and the white gulls (and quick foxes scavenge; are the scavengers).
#2: The bears eat lemmings, and other animals dig up berries; The large bears are white and the small bears are yellowish.
#3: The bears are large and white, and the foxes are white and quick, and the gulls are small and shrill.
#4: Same; Thus the large pure white polar bears are said to live on the ice, while the small yellowish polar bears are said to inhabit the land.

#5: In the Arctic, the bears eat lemmings; The Arctic foxes have small square ears, short sharp muzzles, narrow little bodies, (and fluffy white fur).

#6: Thus the large pure white polar bears are said to live on the ice . . .

#7: ( . . . while) the small yellowish polar bears are said to inhabit the land; The white gulls and quick foxes are persistent scavengers; The large pure white polar bears live on the ice; (Bears, gulls, and foxes; Bears and gulls and foxes (and lemmings); Bears, gulls, foxes, and lemmings; Gulls, foxes, lemmings, and bears; Foxes, lemmings, bears, and gulls; Lemmings, bears, gulls and foxes) live in the Arctic.

#8: The gulls and foxes (scavenge; are scavengers); The big white bears hunt; The shrill white gulls scavenge; The big bears hunt and kill, (and the white gulls and quick foxes scavenge); The big bears are the hunters and killers, and the white gulls are the scavengers; The bears in the Arctic eat lemmings; The bears eat lemmings, and other animals dig up berries; The bears in the Arctic live on the ice in the winter; The large bears are white, and the small bears are yellowish; Bears and gulls live in the Arctic; The Arctic foxes have small square ears, (short sharp muzzles, (narrow little bodies, (and fluffy white fur))).

#9: The Arctic foxes have small square ears and short sharp muzzles; The bears eat lemmings and (many) other (small) animals; The bears are clever hunters and dangerous killers.

#10: The bears (eat lemmings in the summer; live on the ice with the gulls in the winter).

Table 129: Clause-internal Continuation Rises as a function of the number of content words in the clause.

Table 130: #1: Joe won the race and left the city.
#2: Joe both won the race and left the city.

Table 131: #1: He drinks coffee with meals and on the run.
#2: He drinks coffee both with meals and on the run.

Table 132: #1: This flounder should be cooked carefully.
#2: This flounder you should cook carefully.
#3: This flounder, it should be cooked carefully; This flounder, you should cook it carefully.

Table 133: #1: You should carefully cook the flounder.
#2: You should carefully cook it, the flounder.
#3: You should cook it carefully, the flounder.
Table 134:  
#1: I find skiing downhill exciting.  
#2: I find it exciting skiing downhill.

Table 135:  
#1: There are many books I know that are worth reading.  
#2: There are many books, I know, that are worth reading.

Table 136:  
#1: I know Joe was in error.  
#2: I know, Joe was in error.

Table 137:  
#1: The whole morning Marcia paced back and forth.  
#2: Marcia paced back and forth the whole morning.

Table 138:  
#1: Unaware of the danger, Peter was playing pool.  
#2: Peter was playing pool, unaware of the danger.

Table 139:  
#1: Joe grew cotton to make money.  
#2: Joe grew cotton, to make money.

Table 140:  
#1: Joe ran the race, like Bob ran his lawnmower.  
#2: Joe ran the race, like Bob his lawnmower.

Table 141:  
#1: John studied Mary, and Bill studied Jane.  
#2: John studied Mary, and Bill, Jane.  
#3: John studied with Mary, and Bill studied with Jane.  
#4: John studied with Mary, and Bill with Jane.

Table 142:  
#1: Joe bought a chair, Sue bought a carpet, and George bought three beads.  
#2: Joe bought a chair, Sue a carpet, and George three beads.

Table 143:  
#1: George relies on his business friends, and he also relies on his social friends.  
#2: George relies on his business friends, and also relies on his social friends.  
#3: George relies on his business friends and relies on his social friends.  
#4: George relies on his business friends and on his social friends.  
#5: George relies on his business friends and his social friends.  
#6: George relies on his business and on his social friends.  
#7: George relies on his business and social friends.

Table 144:  
#1: Robert hasn’t bought the car yet, but he will buy it later today.  
#2: Robert hasn’t bought the car yet, but he will later today.

Table 145:  
#1: Robert might drive to the store, Sharon has, and George will.  
#2: Robert might, Sharon has, and George will drive to the store.
Table 146:  #1: Emily may be, and all agree that Susan definitely looks, pregnant.
#2: Simon very quietly, and Peter much more noisily, left home today.
#3: We inspected, and were truly amazed by, his garden.
#4: He tripped over, and sat down on, the stool.
#5: Pete looks like, and Sam is, a foreigner.
#6: Joe felt hostile to, and afraid of, his neighbor.
#7: John hit, and Alice caught, the baseball.
#8: Joseph saw and Susan heard the accident happen.
#9: If Sue does and Bill doesn't show up, we'll leave.
#10: John walked onto and through the sand.
#11: John walked on and in the sand.
#12: He totally baffles and utterly amazes me.

Table 147:  #1: Robert might drive to the store, and Sharon might drive to the store too.
#2: Robert might drive to the store, and Sharon might drive too.
#3: Robert might drive to the store, and Sharon might too.
#4: Robert might drive to the store, and Sharon too.

Table 148:  #1: The large pure white polar bears live on the ice.
#2: The small yellowish polar bears live on the land.
#3: We watched the very quickly rising waters in apprehension.
#4: We watched the large yellow racing bicycle in amazement.
#5: Joe needs 10 more able men.
#6: John's energetically building the boat surprised us all.
#7: Carl observed five at-first-sight strange men.
#8: Joe asked Robert's father's sister's husband to eat some fish.
#9: Joe spotted the extremely conspicuous garages.
#10: We must follow Vermont state government's priority-funding established guidelines.

Table 149:  Successive alternating peaks and valleys for utterances in set G, as a function of the number of Sub-contours and whether the sentence had more than one clause.

Table 150:  #1: (The) bears hunt; The gulls scavenge.
#2: The bears are hunters (and killers); Bears eat lemmings.
#3: The bears live (on the ice; with the gulls); Bears live in the Arctic.
#4: The bears eat lemmings in the summer.
#5: The bears eat lemmings and (many) other (small) animals.
#6: The bears eat lemmings, and other animals dig up berries; The bears hunt for lemmings, and dig up berries.
#7: The bears are clever hunters and dangerous killers.
#8: The bears live on the ice in the winter.
#9: The bears in the Arctic eat lemmings.
Bears and gulls live in the Arctic; The gulls and foxes (scavenge; are scavengers).

Bears, gulls, and foxes live in the Arctic.

(Bears, gulls, foxes, and lemmings; Gulls, foxes, lemmings, and bears; Foxes, lemmings, bears, and gulls; Lemmings, bears, gulls, and foxes) live in the Arctic.

The bears in the Arctic live on the ice in the winter.

The bears live on the ice with the gulls in the winter.

The bears are large and white, and the foxes are white and quick, and the gulls are small and shrill.

Bears and gulls and foxes live in the Arctic.

Bears and gulls and foxes and lemmings live in the Arctic.

The big bears (hunt; kill); The white gulls scavenge.

The big white bears hunt.

The big bears hunt and kill.

The white gulls and quick foxes scavenge.

The Arctic foxes have small square ears.

The large bears are white, and the small bears are yellowish; The big bears hunt and kill, and the white gulls and quick foxes scavenge; The big bears are the hunters and killers, and the white gulls are the scavengers.

The Arctic foxes have small square ears, short sharp muzzles, (narrow little bodies, (and fluffy white fur)).

The white gulls and quick foxes are persistent scavengers.

The small yellowish polar bears live on the land.

The large pure white polar bears live on the ice.

The gulls and foxes scavenge.

The shrill white gulls scavenge.

In the Arctic, the bears eat lemmings.

Thus the large pure white polar bears are said to live on the ice, while the small yellowish polar bears are said to inhabit the land.

Table 151:  #1: This car will be built on the road.
#2: This car will be cleaned on the road.
#3: This car will be tested on the road.
#4: This car will be destroyed on the road.
#5: This car will be visited on the road.
#6: This car will be demolished on the road.
#7: This car will be demonstrated on the road.
#8: This car will be identified on the road.
#9: This car will be contaminated on the road.

Table 152:  #1: Almost all of the meat was eaten.
#2-4: Same (but at faster rates)

Table 153:  #1: We watched the very quickly rising waters in apprehension.
#2-4: Same (but at faster rates)

Table 154:  #1: We watched the large yellow racing bicycle in amazement.
#2-4: Same (but at faster rates)
Table 155:  #1: Joe needs ten more able men.  
            #2-4: Same (but at faster rates)

Table 156:  #1: John's energetically building the boat surprised us all.  
            #2-4: Same (but at faster rates)

Table 157:  #1: Carl observed five at-first-sight strange men.  
            #2-4: Same (but at faster rates)

Table 158:  #1: Joe asked Robert's father's sister's husband to eat some fish.  
            #2-4: Same (but at faster rates)

Table 159:  #1: Joe spotted the extremely conspicuous garages.  
            #2-4: Same (but at faster rates)

Table 160:  #1: We must follow Vermont state government's priority-funding established guidelines.  
            #2-4: Same (but at faster rates)

Table 161:  #1: Joe performed qualitative analysis on the samples.  
            #2-4: Same (but at faster rates)
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| 5 | neg contr | 4 | 157 | -6 | 2 | 153 | -15 | * | -7 | 9 | 140 | -27 |
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| 2 | gray helm | 1 | 182 | -35 | 18 | 165 | -57 | 23 | 128 | -4 | 9 | 133 | 1 |
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Table 71

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| 1 | preposed       | JA    | 2 | 171| 0  | 37 | 174| -67| +13| 31 | 141| -53|
| 2 | dummy-inserted | 4     | 196| 180| 0  | 35 | 181| -71| +14| 38 | 151| -57|
| 3 | cleft or pseudo-cleft | 4 | 197| 0  | 30 | 190| -80| 0  | 28 | 139| -21| 29 | 129|
| 4 |                | KS    | 1 | 173| 0  | 40 | 149| -59| +13| 31 | 132| -49|
| 5 |                | 2     | 156| 133| -2 | 33 | 133| -42| +10| 39 | 128| -51|
| 6 |                | 2     | 155| -5 | 39 | 146| -71| 0  | 22 | 107| -21| 14 | 97|
| 7 |                | DO    | 1 | 127| -5 | 24 | 128| -43| 0  | 34 | 120| -47|
| 8 |                | 2     | 122| 125| -4 | 25 | 132| -55| 0  | 40 | 129| -59|
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### Table 94

| #  | code    | sp | N | set H | these | red | pencils | yours | mine? | yours | mine? | yours | mine? | yours | mine? | yours | mine? |
|----|---------|----|---|-------|-------|------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1  | pencils? | JA | 1 | 158  | -19 | 4   | 143   | -3   | 21   | 161  | 20   | 11   | 192  |   |     |     |
| 2  | yours?   |    | 1 | 161  | -14 | 11  | 158   | -25  | 29   | 162  | -42  | 72   | 192  |   |     |     |
| 3  | mine?    |    | 1 | 147  | -16 | 40  | 171   | -3   | 26   | 192  | -66  | 54   | 180  | *  | 129  | -41  |

### Table 95

| #  | code          | sp | N | set H | coffee or soda | else? | coffee | or | soda | else? | coffee | or | soda | else? | coffee | or | soda | else? | coffee | or | soda | else? | coffee | or | soda | else? |
|----|---------------|----|---|-------|----------------|-------|--------|-----|-----|-------|--------|-----|-----|-------|--------|-----|-----|-------|--------|-----|-----|-------|--------|-----|-----|-------|--------|
| 1  | coffee or soda?..else? | JA | 1 | 56   | 167  | -27 | 13  | 35 | 162 | 0    | 42   | 204| 14 | 142 | -66  |     |     |     |

### Table 96

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<td>198 -31 27 155 -5 0 9 143</td>
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### Table 103

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<td>(Sma and Joe)</td>
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<td>198 -74 14 52 162 -8 0 148 20 123</td>
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### Table 104

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### Table 105

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<td>1 154 -29 63 188 -40 -73 72 147</td>
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<td>(John (also;only))..</td>
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|    |                |    |    |       |        |      |        |        |        |      |      |
| 5  | (John (also;only))... | |    |       |        |      |        |        |        |      |      |
| 6  | (John (even)...
|    |                |    |    |       |        |      |        |        |      |      |
| 7  | ..cooked (also;only) | |    |       |        |      |        |        |        |      |      |
| 8  | ..cooked even...
|    |                |    |    |       |        |      |        |        |      |      |
| 9  | ..fish (also;only).
|    |                |    |    |       |        |      |        |        |      |      |
| 10 | ..fish even. | |    |       |        |      |        |        |        |      |      |
| 11 |                | KS | 1  |       |        |      |        |        |        |      |      |
| 12 |                |    |    |       |        |      |        |        |        |      |      |
| 13 |                |    |    |       |        |      |        |        |        |      |      |
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| 15 |                |    |    |       |        |      |        |        |        |      |      |
| 16 |                |    |    |       |        |      |        |        |        |      |      |
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| 18 |                |    |    |       |        |      |        |        |        |      |      |
| 19 |                |    |    |       |        |      |        |        |        |      |      |
| 20 |                |    |    |       |        |      |        |        |        |      |      |
| 21 |                | DO | 1  |       |        |      |        |        |        |      |      |
| 22 |                |    |    |       |        |      |        |        |        |      |      |
| 23 |                |    |    |       |        |      |        |        |        |      |      |
| 24 |                |    |    |       |        |      |        |        |        |      |      |
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Table 107

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<th>Robert/Mr. Jones</th>
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Table 108st H

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Table 109 set H

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Table 110 set G

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Table 111 set G

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## Table 112

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## Table 113

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### Table 123

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### Table 124

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### Table 125

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Table 130

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Table 131

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<td>We watched the very quickly.</td>
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Table 154

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Table 155

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<th>ten</th>
<th>more</th>
<th>able</th>
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Table 156

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<th>#</th>
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<th>energetically</th>
<th>building</th>
<th>boat</th>
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<td>pk</td>
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### Table 157

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<th>#</th>
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<th>set H</th>
<th>five</th>
<th>at</th>
<th>first</th>
<th>sight</th>
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<td>Carl observed at-first-sight..</td>
<td>JA</td>
<td>1.10</td>
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### Table 158

<table>
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<tr>
<th>#</th>
<th>code</th>
<th>set H</th>
<th>Joe asked</th>
<th>Robert's father's</th>
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<td>Joe asked Robert's father's..</td>
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### Table 159

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<th>extremely conspicuous garages</th>
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### Table 160

<table>
<thead>
<tr>
<th>#</th>
<th>code</th>
<th>set H</th>
<th>Vermont state government priority funding established guides</th>
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### Table 161

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<th>#</th>
<th>code</th>
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<th>qualitative analysis samples</th>
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Biographical Note

Douglas O'Shaughnessy

Born on February 20, 1950, in New York City, I spent the years through high school on Long Island. Since 1967 (except undergraduate summers), Cambridge, Massachusetts has been my residence, while I have studied at M.I.T. The recipient of four degrees (a bachelor's, master's and E. E. in Electrical Engineering; and a bachelor's in math) in 1972, I was favored to receive an undergraduate scholarship from the W. T. Grant Co. and a graduate fellowship from the National Science Foundation. Elected to the engineering honoraries of Eta Kappa Nu and Tau Beta Pi, I served as an officer in the E. E. society. Three recent summers were spent in E. E.-related jobs: two at a small electronics firm, testing and designing circuits, and one at an acoustic research laboratory, writing a computer software program for automatic speech recognition.

For 2 terms, I was a teaching assistant for the undergraduate course "Signals and Systems." I have authored "Consonant Durations in Clusters," published in the IEEE Transactions on Acoustics, Speech, & Signal Processing, ASSP-22, August 1974, and am in the process of writing (with my advisor) 2 papers based upon this thesis. I gave a talk at the 85th Meeting of the Acoustical Society (1973), based upon my Master's thesis. In my graduate years, I became interested in the areas of speech communication, digital signal processing, pattern recognition, systems modelling, communication, control, probabilistic systems, operations research, and linguistics. These are the fields in which I have taken graduate courses and wish to pursue further research.