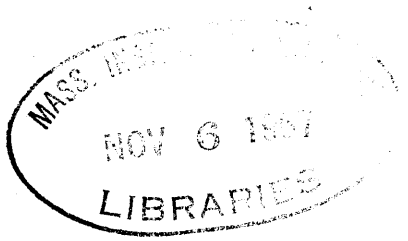


# CHANGE IN THE VISUAL HIGHWAY

By

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B. Arch., Carnegie Institute of Technology, 1965

Submitted in Partial Fulfillment

of the Requirements for the

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# CHANGE IN THE VISUAL HIGHWAY

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Submitted to the Department of City and Regional Planning on May 19, 1967, in partial fulfillment of the requirements for the degree of Master of City Planning.

This study attempts to gain some understanding of how the driver perceives the highway environment. Part I of this study presents a laboratory investigation in which drivers and non-drivers were shown a movie and slides taken on an urban highway. The movie-slide variable presented the opportunity to study subjects' reactions to the same scenes with and without motion. The driver-non-driver variable offered the possibility of gaining insight into how the driving task influences driver perception.

Part II of this study presents literature from the fields of perception psychology, physiology and driver analysis which may be useful in further driver studies.

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# PART I - LABORATORY INVESTIGATION

## Purpose

In today's urban centers, the demand for more highways has collided with the need to use urban land more intensively. The result is that new highways are often allotted only enough width to accommodate the pavement and only enough height to permit truck travel. Some of these roads have proven to be pleasant to drive on, but others have not. The purpose of this study was to gain some understanding of the basis on which highway users may judge a highway of limited right-of-way pleasant or unpleasant. To explore this problem a laboratory investigation was conducted.

## The Investigation

The investigation consisted of presenting a movie and slides of an urban highway of limited right-of-way to drivers and non-drivers. The movie-slide variable presented the opportunity of examining subjects' reactions to the same highway scene with and without change (visual motion) the scene elements remaining the same. The driver-non-driver variable offered the possibility of gaining some insight into how the driving task influences a driver's judgment of pleasantness.

The east-bound half of the Boston Extension of the Massachusetts Turnpike was selected as the study route because it repeats several basic urban highway situations with numerous variations. It was felt that

these variations would provide interesting comparisons, useful in studying the effects of scene elements. The movie represented travel at a speed of 60 MPH and presented the environment in short one and one-half second scenes separated by six second blank spaces. One and one-half seconds is enough time to present a scene and a sense of motion, but short enough that the scene elements are unlikely to change. The six second blank spaces insured that the subjects reacted to only one scene at a time. Twenty-eight scenes were made and randomly arranged. A slide was made from the center frame of each movie scene to present the same scene, but without motion.

Typically, the subject was placed before a large wall in a darkened room. The slides and movie were projected onto the wall such that the subject experienced approximately the proper perspective and some peripheral vision. The subject was instructed to watch the movie and judge each scene "liked" or "disliked". The subject recorded his response on paper provided. This "liked-disliked" response was designed to record the subjects' first impressions of each scene for use in a subjective analysis that will be discussed later.

After all twenty-eight scenes were viewed, the subjects' answer-sheet was collected. He was reshown the movie, but this time, the projector was stopped after each scene and the subject was asked to verbally comment on why he thought he had made his initial "liked-disliked" response. He was not told what the first response had been.

This second response served three functions. First, it provided an open-ended opportunity for the subject to express why he thought he liked or disliked the scene. Secondly, it gave the subject the chance to express that although he liked a scene in general, he disliked some aspect of it or visa-versa. And lastly, consistency between the subject's first response (liked-disliked) and the second response (comment) would give some indication how rational his judgments were. This verbal comment was designed as the basic source of data for the analysis of subjects' reactions to the scenes.

After seeing the movie a second time, the subject was given a break and taken from the room. When he returned, he was again seated before the large wall and the entire procedure as described above was repeated but using the slides instead of the movie.

The investigation was repeated for eight drivers and eight non-drivers. Half of the drivers and half of the non-drivers viewed the slide presentation before they saw the movie.

When questioned, the subjects uniformly felt that the presentation was realistic and that the movie gave them a sense of motion. They accepted it as a simple investigation into what makes a highway pleasant, and appeared to enjoy it.

## Findings

As was mentioned above, the "liked-disliked" response was designed for use in a subjective analysis. It was anticipated that this type

of response in itself would yield very little information because it was a simple response (two choices) to a very complex matrix of stimuli (the entire scene) with no objective means of connecting the response with the particular stimulus or group of stimuli that triggered it. Let it suffice for now to mention that subjects balanced their "liked-disliked" responses about 50-50. The most "liked" responses that any one subject gave was 17 out of 28 (60%), the least was 8 out of 28 (29%). Subjects, particularly drivers, often changed their minds between the movie and the slide presentations of the same scene (approximately 10 times out of 28), but subjects rarely changed their minds about a particular scene between the first and second showing of the same media (one or two times out of 28). This suggests that subjects were rational rather than random in making their responses.

The verbal comments were listed by the variables driver-non-driver and movie-slides. Because the comments were open-ended, they spanned a great range of subject matter and wording. It was therefore necessary to develop a system for grouping comments under a manageable number of headings for analysis. Inspection revealed that subjects had referred to both "Scene Elements" ("the road" or "the view") and to "Scene Qualities" ("it's interesting"). Comments about Scene Elements were collected under four headings:

A. <u>On the Road</u> - mention of any object on or connected to the road, i.e. pavement, guardrail, or overpass.

B. Off the Road - mention of any object in the scene not spatially related to the road i.e. buildings, trees and billboards.

C. View - mention of the ability to see into the distance ahead.

D. No View - mention that the view ahead was blocked by some object (overpass) or cut off by the configuration of the road (sharp curve).

Comments about Scene Qualities were collected under eight headings:

A. Composition - mention that the subject liked or disliked the scene compositon in the graphic sense.

B. (1) Had Interest - mention that the subject generally found the scene interesting or stimulating, without specific cause.

(2) Lacked Interest - mention that the subject found the scene 'boring' or 'dull', without specific cause.

C. (1) Focus or Good Orientation - mention that the subject felt focused or well-oriented in the scene i.e. "it's clear where I'm headed".

(2) Confusing or Poor Orientation - mention that the subject felt confused, could not figure out where he was or was generally disoriented "I don't understand the scene".

D. Sense of Self-Motion - mention that the subject felt a sense of motion and the changing relationships between himself and the objects in the scene i.e. "plunging into that tunnel".

E. (1) Relaxed or Safe Feeling - mention that the subject felt relaxed, at ease, safe or free from anxiety "that's a relaxing view".

(2) Stressed or Unsafe Feeling - mention that the subject felt threatened, in danger, anxious, afraid or unsafe. "I was afraid I was going to hit the wall."

Comments that mentioned a scene element and a scene quality were scored once under both headings. Comments such as "it looks like the Bronx", "it's ugly", "it's pretty", and "it's so-so" were dropped as being too general. Chart I illustrates how forty-five typical comments were collected under the twelve headings.

CHART I

SAMPLE COMMENTS

| SUBJECT'S COMMENTS | SCENE ELEMENTS | | | | | SCENE QUALITIES | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | On the Road | Off the Road | View | No View | Composition | Had Interest | Lacked Interest | Focus Or Good Orientation | Confusing Or Poor Orientation | Sense Of Self-Motion | Relaxed Or Safe | Stressed Or Unsafe |
| liked view | | | X | | | | | | | | | |
| disliked overpass | X | | | | | | | | | | | |
| nice sense of what's going on | | | | | | | | X | | | | |
| overpass blocked the view | X | | | X | | | | | | | | |
| generally interesting | | | | | | X | | | | | | |
| no focus | | | | | | | | | X | | | |
| so much of the same | | | | | | | X | | | | | |
| like distant bldg. in the view | | X | X | | | | | | | | | |
| confusing | | | | | | | | | X | | | |
| curve in road | X | | | | X | | | | | | | |
| composition of scene | | | | | | | | | | | | |
| sense of approach | | | | | | | | | | X | | |
| composition of buildings | | X | | | X | | | | | | | |
| relaxed feeling | | | | | | | | | | | | |
| emerging from tunnel | X | | | | | | | | | X | | |
| too close to edge of road | X | | | | | | | | | | | X |
| nothing to look at | | | | | | | X | | | | | |
| view cut off | | | X | | | | | | | | | |
| fear heavy wall | X | | | | | | | | | | | X |
| I feel safe | | | | | | | | | | | X | |
| too much road | X | | | | | | | | | | | |
| lacks interest | | | | | | | X | | | | | |
| nice grouping of things | | | | | X | | | | | | | |
| like Prudential in distance | | X | X | | | | | | | | | |
| plunging into tunnel | X | | | | | | | | | X | | |
| dull, boring | | | | | | | X | | | | | |
| restful scene | | | | | | | | | | | X | |
| going too fast | | | | | | | | | | X | | X |
| can't see where I'm going | | | | | | | | | X | | | |
| bleak | | | | | | | X | | | | | |
| stimulating view | | | X | | | X | | | | | | |
| I feel unsafe | | | | | | | | | | | | X |
| nice orientation | | | | | | | | X | | | | |
| great shapes | | | | | X | | | | | | | |
| buildings block view | | X | | X | | | | | | | | |
| doesn't scare me | | | | | | | | | | | X | |
| swallowed-up | | | | | | | | | | X | | |
| nice composition | | | | | X | | | | | | | |
| panorama | | | X | | | | | | | | | |
| dangerous situation | | | | | | | | | | | | X |
| quiet open view | | | X | | | | | | | | X | |
| looks safe | | | | | | | | | | | X | |
| going very slow | | | | | | | | | | X | | |
| clear road ahead | X | | | | | | | X | | | | |
| nothing dominant | | | | | | | X | | | | | |

Chart II shows the distribution of these comments by heading.

CHART II

DISTRIBUTION OF COMMENTS

| TYPES OF COMMENTS | COMMENTS ON MOVIE SCENES | | COMMENTS ON SLIDE SCENES | |
|---|---|---|---|---|
| | Drivers | Non-Drivers | Drivers | Non-Drivers |
| SCENE ELEMENTS | | | | |
| On the Road | 25 | 6 | 9 | 3 |
| Off the Road | 19 | 49 | 31 | 37 |
| View | 14 | 15 | 12 | 19 |
| No View | 24 | 9 | 12 | 11 |
| SCENE QUALITIES | | | | |
| Composition | 7 | 49 | 36 | 52 |
| Had Interest | 13 | 10 | 6 | 2 |
| Lacked Interest | 2 | 21 | 31 | 25 |
| Focus or Good Orientation | 12 | 3 | 7 | 5 |
| Confusing or Poor Orientation | 19 | 5 | 3 | 5 |
| Sense of Self-Motion | 30 | 18 | 4 | 2 |
| Relaxed or Safe Feeling | 15 | 4 | 2 | 3 |
| Stressed or Unsafe Feeling | 38 | 10 | 3 | 1 |

Under the heading "Scene Elements" there are several interesting results. In the movie, drivers commented more about "On the Road" elements than non-drivers (25 for drivers vs. 6 for drivers) and non-drivers commented more about "Off the Road" elements than drivers (49 for non-drivers vs. 19 for drivers). In the slides drivers and non-drivers mentioned "On the Road" and "Off the Road" elements in similar proportions. This suggests that drivers look more to road related objects than passengers who look more randomly.

Although in the movie, drivers and non-drivers mentioned the "View" nearly an equal number of times (14 for drivers vs. 15 for non-drivers). Drivers mentioned the absence of a view (No View) 24 times whereas non-drivers mentioned this only 9 times. In the slides, drivers and non-drivers mentioned the presence or lack of a view a similar number of times (12 vs. 11). The distribution of these comments suggests that drivers and non-drivers or passengers might look at the view in about equal amounts, but should the view be blocked, drivers would miss the view more than passengers.

The Category "Scene Qualities" also suggests several interesting results. Drivers and non-drivers watching slides made 36 and 52 comments about composition respectively. This is by far the largest group of comments about slides and suggests that in static situations composition is an important criteron in judgement. Non-drivers watching the movie mentioned composition 49 times, which suggests that composition

was still an important criterion for them in judging scenes in motion. However, drivers watching the movie mentioned composition only 7 times (36 times watching the slides) which indicates that for them composition was no longer very important.

Under the heading "Had Interest" drivers and non-drivers commented in approximately equal amounts (13 vs. 10 for movie, 6 vs. 2 for slides) but under the heading "Lacked Interest" there is considerable variation. Non-drivers mentioned "Lacked Interest" type comments 21 times for the movie and 25 times for the slides, suggesting that they were "bored" about equally by the movie and the slides. On the other hand, drivers were bored 31 times watching the slides, but only twice during the movie. This pattern of comments closely parallels the distribution of comments on "Composition" and collectively they suggest that non-drivers, because they are making similar types of comments about the movie and the slides, may be using similar criteria in judging the movie and the slides, whereas the drivers are making significantly different types of comments which suggests that they may be using different criteria.

Under the headings "Focus or Good Orientation" and "Confusing or Poor Orientation" drivers watching the movie were the only group to mention these types of comments in any significant numbers (12 and 19 for drivers watching the movie vs. a range of 7 to 3 for non-drivers and slide watchers). This suggests that drivers value a sense of

orientation and good comprehension of scene more than non-drivers. This complements the earlier finding that drivers complained of no view ahead which could be one source of disorientation.

The headings "Sense of Self-Motion", "Relaxed or Safe Feeling" and "Stressed or Unsafe Feeling" further reveal a split between drivers and non-drivers watching the movie. Comments under the heading"Sense of Self-Motion" were about the changing relationships sensed by the subject between himself and the objects in the scene e.g. "plunging into", "bursting out of" or "speeding through". Thirty times drivers watching the movie made such comments, whereas non-drivers made only 18 such comments. This would suggest that drivers were more aware of or attached more importance to these changing relationships than non-drivers did.

Under the heading "Relaxed or Safe Feeling" drivers made 15 comments during the movie whereas non-drivers made only four. This suggests that drivers were more concerned about their comfort and safety than non-drivers. And under the last heading "Stressed or Unsafe Feeling" drivers made 38 comments whereas non-drivers made only ten. This suggests that drivers felt threatened, unsafe or anxious nearly four times as often as non-drivers did.

These last two headings further support the suggestion made under the heading "Sense of Self-Motion" that drivers were mindful of some relationships between the scene and themselves that had little effect on non-drivers.

These comments and the suggestions drawn from them prove nothing about drivers or non-drivers. There is no guarantee that real drivers or passengers in real highway situations would react in a similar manner to that of the subjects. In particular, the presentation was free from any threat of accident. It also ignored the sequential aspects of real highway travel by presenting only flashes of scenes, and it ignored the motor-sensory feedback loop that drivers normally experience in driving. Lastly, it largely ignored peripheral vision which may play an important role in motion perception.

Despite these shortcomings, the findings do collectively suggest a conceivable explanation for why drivers commented in a different manner than non-drivers. Comments by drivers and non-drivers during the slides show a great similarity in distribution. In particular, the large number of comments by both drivers and non-drivers under the headings "Off the Road" elements and "Composition" suggest that perhaps subjects watching static scenes used the presence of general scene elements (Off the Road) and their relationships to one another (Composition) as a basis for judging the scene pleasant or unpleasant. This is generally consistent with theories on aesthetics.

The distribution of comments by non-drivers watching the movie shows a strong similarity to the comments slide watchers made. This similarity is particularly strong under the three headings "Off the Road Elements", "Composition", and "Lacked Interest", which contain 60%

of all non-driver movie comments. This parallel suggests that non-drivers adapted or extended static picture watching criteria to the motion situations of the movie; that they based their judgements on the presence of scene elements and the changing relationships that existed between elements.

There is a real division in the distribution of comments between drivers watching the movie and the three previously discussed groups. It would seem logical that any explanation of this division must make a distinction between drivers watching the movie and drivers watching the slides and drivers and non-drivers. Conditioning by the driving task would appear to be that distinction.

The driving task is most often thought of as a motor-sensory feedback loop in which the driver makes judgements about where he is, where he is going to be next and how fast he will get there. If it appears that he will get there safely, the driver maintains his current course; if not, he makes an adjustment. He repeats this loop over and over again each time with new judgements about his location, heading and speed. Information about current location, heading, and speed is judged by monitoring the change in the visual relationships between himself and the road objects around him. This would suggest that a driver watching the movie had been conditioned by the driving task to be primarily concerned with the road related elements and their changing relationships with himself.

This explanation of driver behavior is supported by the conclusions suggested by the analysis of driver comments from the movie. Under the heading "On the Road" it was suggested that divers paid more attention to road related scene elements than non-drivers did. The distribution of comments under the headings "No View", "Focus or Good Orientation", and "Confusing or Poor Orientation" suggested that drivers valued a look ahead and good orientation and that loss of orientation or confusion distressed them. The results of the heading "Composition" suggested that drivers paid little attention to the relationships between scene elements. This is consistent with the explanation. The findings that drivers were more sensitive to apparent self-motion and to their own sense of well-being suggests that they indeed felt a relationship between the movie scene and themselves.

In summary, it is suggested that drivers have been conditioned by the driving task to be primarily concerned with road related scene elements and the changing relationships between these elements and themselves, whereas non-drivers not conditioned by the driving task, are concerned more with general scene elements and the changing relationships among elements. However, it would be logical to assume that drivers could on occasions appreciate general scene elements and their changing composition the same as non-drivers do, and that non-drivers who have highway experience as passengers, could appreciate the changing relationships between the scene elements and themselves as drivers do.

From the suggestions and subjects' comments in general a series of hypotheses can be formulated as to what makes a road pleasant or unpleasant.

Hypotheses

(1) That drivers have been conditioned by the driving task to attend to the visual change in highway scenes.

(2) That drivers attend to visual change in road related elements more than to general scene elements.

(3) That drivers prefer scenes that provide:

a. a strong road definition to aid in determining lateral position

b. a good view of the road ahead in order to be able to anticipate new situations

c. a static reference to help point out the way ahead

d. enough normal change to present an interesting situation but not so much as to be stressful.

(4) That non-drivers, not conditioned by the driving task, attend more to scene composition than to visual change.

(5) That non-drivers prefer scenes that provide;

a. a variety in the size or shape of elements in the skyline

b. a focus or dominant feature to attract attention.

To test these hypotheses, each scene was analyzed for the four

driver criteria in Hypothesis 3 and the two non-driver criteria in Hypothesis 5. The amount of visual change in each scene was determined by making a double exposed photograph from two close, but not adjacent frames. The distance that an element in a scene moved from the first image to the second image was measured as the amount of change that it had undergone in the subjects' visual field. The range of measurements were divided into four arbitrary groups. All elements that exhibited no change were defined as Group I. All Elements that exhibited only a slight amount of movement were called Group II. Increasingly larger movements were called Group III and Group IV respectively.

A Change Diagram was then drawn to aid in evaluation of the criteria. These analyses were compared with subjects initial liked-disliked responses as well as their comments to test the usefulness of the hypotheses. Chart III illustrates the analyses rating. Nine representative scenes are presented.

CHART III

SCENE ANALYSIS

Analysis of Driver Criteria

A. Clarity of road - rated poor, moderate or strong on visibility of road edge.

B. View Ahead - rated view of foreground only as poor, view of middleground as moderate, and view into the distance as good.

C. Static reference - rated dominant elements near road and in Group I as strong. Elements too far from the road or too small or in Groups II and II received lower ratings of moderate and weak.

D. Amount of change - rated Group I at center of scene and Group II at sides of scene as low. Scenes with Group I centers and Group III or IV at sides were rated maderate and scenes with Group II or III at the center as high.

Analysis of Non-Driver Criteria

A. Variety in the skyline - rated several elements of different size or shape as good. Scenes with flat horizons were rated poor, and moderate represented a mid-range.

B. Focus or dominant feature - rated the presence of a strong single feature that attracted attention as strong. Competition between elements was rated as moderate and the lack of any strong element was rated poor.

SCENE 4

LIKED - DISLIKED RESPONSES

| | MOVIE | | SLIDES | |
|---|---|---|---|---|
| | Drivers | Non-Drivers | Drivers | Non-Drivers |
| LIKED | 8 | 6 | 8 | 7 |
| DISLIKED | 0 | 2 | 0 | 1 |

Sample Comments to Scene

Drivers watching Movie

(1) "open view, can see guard rail" L

(2) "see Prudential, open view" L

(3) "A relaxing view" L

(4) "simple straight shot ahead" L

Non-Drivers watching Movie

(1) "like the composition" L

(2) "pretty view" L

(3) "well organized scene" L

(4) "too busy, tower, overpass, etc." D

Drivers and Non-Drivers to Slides

(1) "nice composition" L

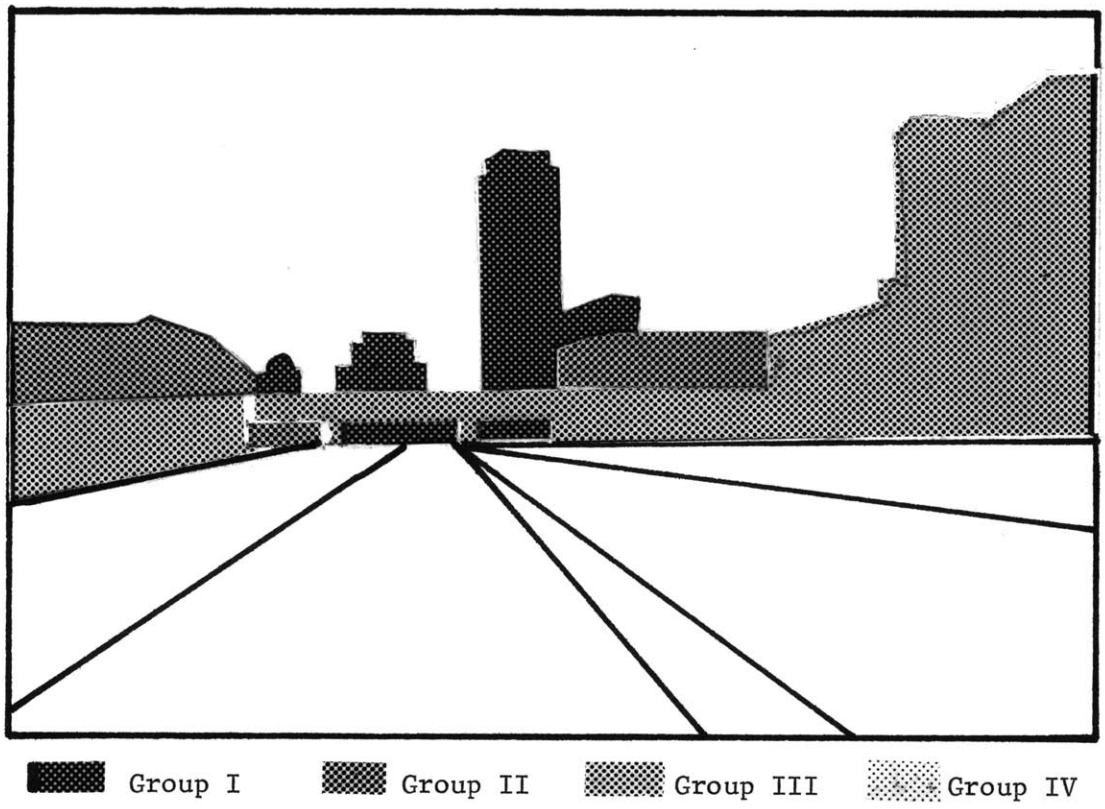
(2) "good orientation, see ahead" L

(3) "Prudential nice" L

(4) "pretty scene" L

L = liked D = disliked

Scene 4




Scene 4 - Change Diagram

SCENE 4

Analysis of Driver Criteria

A. Road definition - strong, the change diagram reveals a clear, readable road edge.

B. View ahead - good, road is visible well into the distance.

C. Static reference - strong, a dominant group of buildings at the end of the road are in Group I

D. Amount of change - moderate, center of scene is in Group I and roadside development is in Group III.

Analysis of Non-Driver Criteria

A. Variety in the skyline - moderate, a combination of large and small shapes.

B. Focus or dominant feature - strong, the tower at the end of the road provides a strong dominant element.

Findings

This was the best liked scene in the movie, receiving 14 liked responses out of a possible 16 from drivers and non-drivers. Drivers, who all liked the scene, commented on the clarity of the road elge, the landmark at the end of the road and the relaxed quality of the view. The analysis of the driver criteria rates clarity of the road as strong, view ahead as good, strength of the static reference as strong and amount of change as moderate. Since this was the best liked scene, the above ratings were assumed to represent optimum levels of each criteria.

Non-drivers, voting six to two in favor of this scene, commented on the scene's composition. The analysis of non-driver criteria rated variety in the skyline as moderate and focus or dominant feature as strong. It is assumed that good variety in the skyline and strong focus or dominant feature represents the optimum in non-driver criteria. In this scene, the ratings of all criteria show good consistancy with subjects responses.

SCENE 8

LIKED - DISLIKED RESPONSES

| | MOVIE | | SLIDES | |
|---|---|---|---|---|
| | Drivers | Non-Drivers | Drivers | Non-Drivers |
| LIKED | 7 | 5 | 5 | 4 |
| DISLIKED | 1 | 3 | 3 | 4 |

Sample Comments on Scene

Drivers watching Movie

| | |
|---|---|
| (1) "clear straight road" | L |
| (2) "good view of road" | L |
| (3) "looks safe, easy to drive" | L |
| (4) "a bit too busy" | D |

Non-Drivers watching Movie

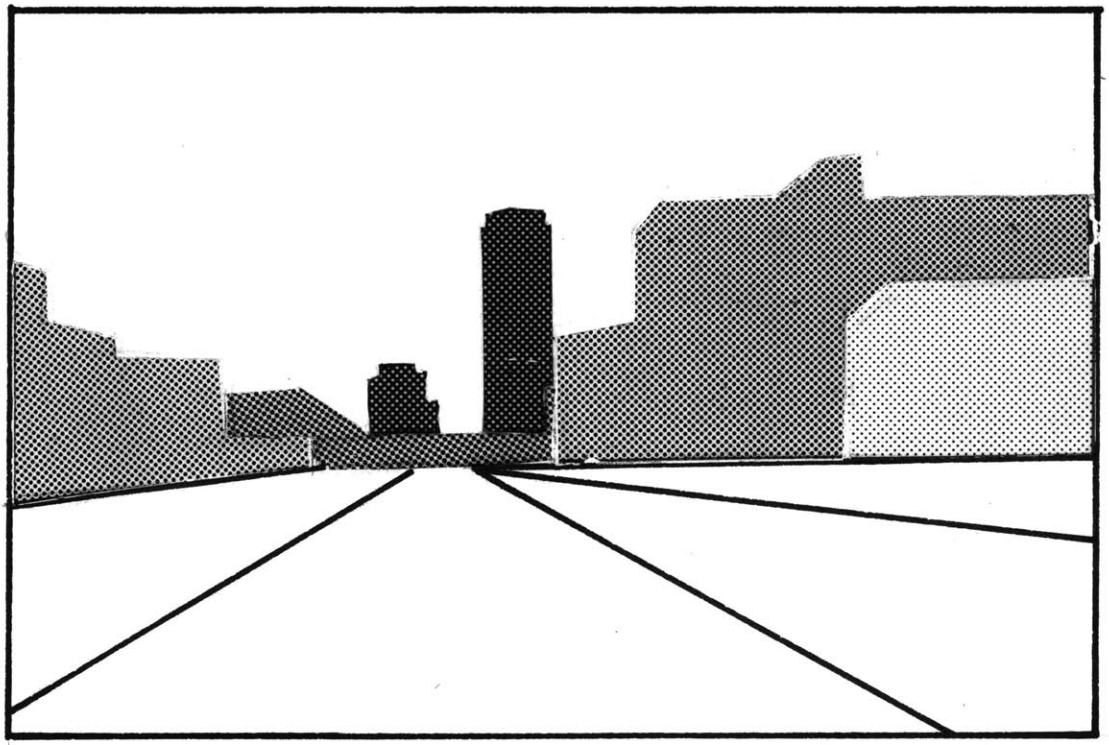
| | |
|---|---|
| (1) "don't like sign" | D |
| (2) "variety of shapes" | L |
| (3) "relationship of sign to Prudential" | L |
| (4) "too much clutter" | D |

Drivers and Non-Drivers watching Slides

| | |
|---|---|
| (1) "like sign" | L |
| (2) "sign distracts" | D |
| (3) "building ugly" | D |
| (4) "contrast foreground with background" | L |

L = liked D = disliked


Scene 8




Scene 8 - Change Diagram

SCENE 8

Analysis of Driver Criteria

A. Clarity of road - strong, the same as Scene 4

B. View ahead - good, same as Scene 4

C. Static reference - moderate, same landmark as in Scene 4, Still in Group I, but smaller and less dominant in the scene.

D. Amount of change - moderate, similar to Scene 4, but roadside development is more complex than in Scene 4 and one building is in Group IV.

Analysis of Non-Driver Criteria

A. Variety in the skyline - moderate, the landmark is too small and the roadside development too big to provide excellent variety.

B. Focus or dominant feature - moderate, landmark and roadside development compete for importance, neither dominates.

Findings

Non-drivers did not receive this scene quite as well as Scene 4, voting only five to three in favor of it. The analysis rates both non-driver criteria as only moderate.

Drivers were also less enthusiastic than they were about Scene 4, but remained generally in favor of the scene, voting seven to one. The analysis of driver criteria reveals that all criteria were rated the same as in Scene 4 except static reference which was rated moderate instead of strong. In both driver and non-driver analysis, one

criterion was rated lower than it had been in Scene 4, and both dirver and non-driver responses were slightly less favorable than in Scene 4. This supports the criterion of static reference and suggest that the criteria in general are sensitive to subjects' responses.

SCENE 22

LIKED - DISLIKED RESPONSES

| | MOVIE | | SLIDES | |
|---|---|---|---|---|
| | Drivers | Non-Drivers | Drivers | Non-Drivers |
| LIKED | 4 | 3 | 3 | 1 |
| DISLIKED | 4 | 5 | 5 | 7 |

Sample Comments on Scene

Drivers watching Movie

| | |
|---|---|
| (1) "looks safe" | L |
| (2) "scene fades away" | D |
| (3) "long smooth lines" | L |
| (4) "dull" | D |

Non-Drivers watching Movie

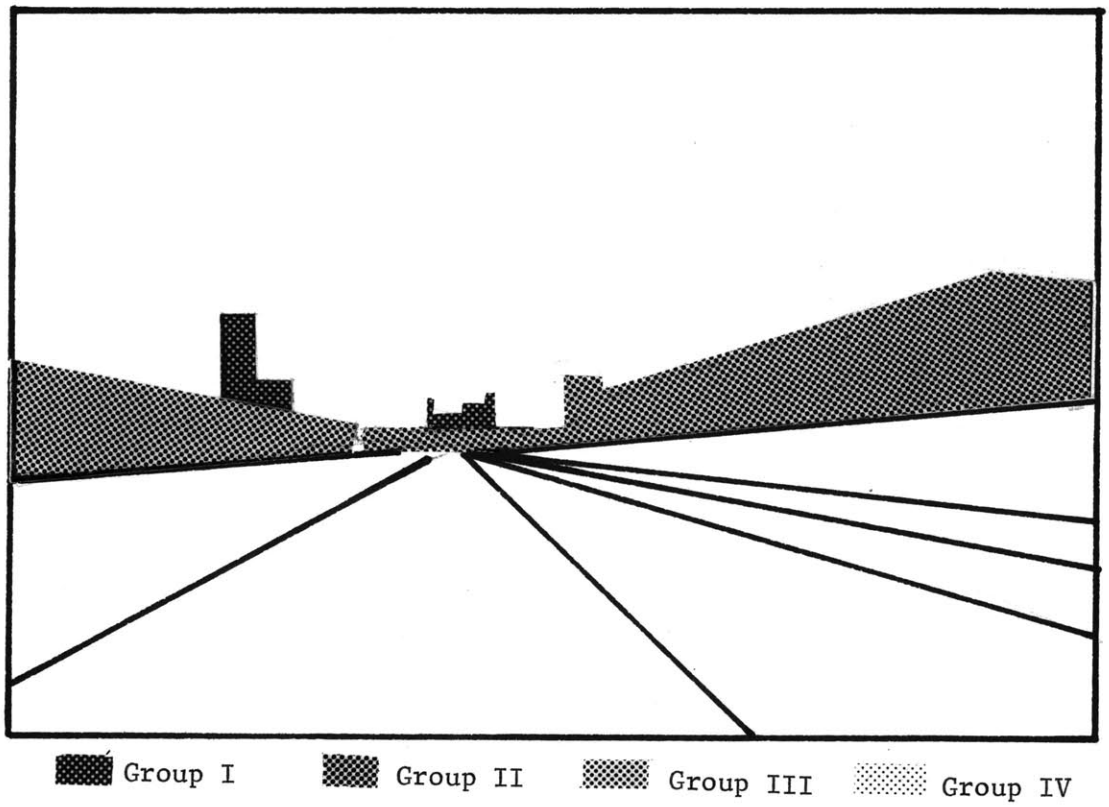
| | |
|---|---|
| (1) "dull" | D |
| (2) "no zip" | D |
| (3) "great sense of distance" | L |
| (4) "going too slow" | D |

Drivers and Non-Drivers watching Slides

| | |
|---|---|
| (1) "dull" | D |
| (2) "no focus" | D |
| (3) "bleak" | D |
| (4) "repetition of lines" | D |

L = liked D.= disliked

Scene 22




Scene 22 - Change Diagram

SCENE 22

Analysis of Driver Criteria

A. Clarity of road - strong, same as 4 and 8

B. View ahead - good, same as Scenes 4 and 8

C. Static reference - poor, the same landmark as in Scenes 4 and 8 but in this scene it is small and offset from the road. The structure at the end of the road is too small to be considered useful.

D. Amount of change - low, roadside development is set back. The scene contains only Group I and Group II.

Analysis of Non-Driver Criteria

A. Variety in the skyline - poor, skyline is very uniform, all elements are about the same height.

B. Focus or dominant feature - poor, nothing dominates the scene.

Findings

Neither drivers nor non-drivers particularly liked this scene. Non-drivers voted five to three against the scene and their comments suggest that they were bored. Both non-driver criteria were rated as poor. Drivers voted four to four on this scene, and their comments suggest a division in feelings . Drivers who liked the scene said the scene "looked safe". Clarity of road and view ahead were both rated strong, but static reference was rated poor. Drivers who disliked the scene found the scene dull and amount of change was rated as low. This suggests that at least some drivers desire a minimum amount of change, perhaps for a sense of progress.

SCENE 10

LIKED - DISLIKED RESPONSES

| | MOVIE | | SLIDES | |
|---|---|---|---|---|
| | Drivers | Non-Drivers | Drivers | Non-Drivers |
| LIKED | 2 | 7 | 5 | 8 |
| DISLIKED | 6 | 1 | 3 | 0 |

Sample Comments on Scene

Drivers watching Movie

(1) "confusing" D

(2) "unsafe" D

(3) "too close to guard rail" D

(4) " a lot of things going on" L

Non-Drivers watching Movie

(1) "variety of forms" L

(2) "very exciting" L

(3) "great shapes, great view" L

(4) "don't like sign" D

Drivers and Non-Drivers watching Slides

(1) "composition" L

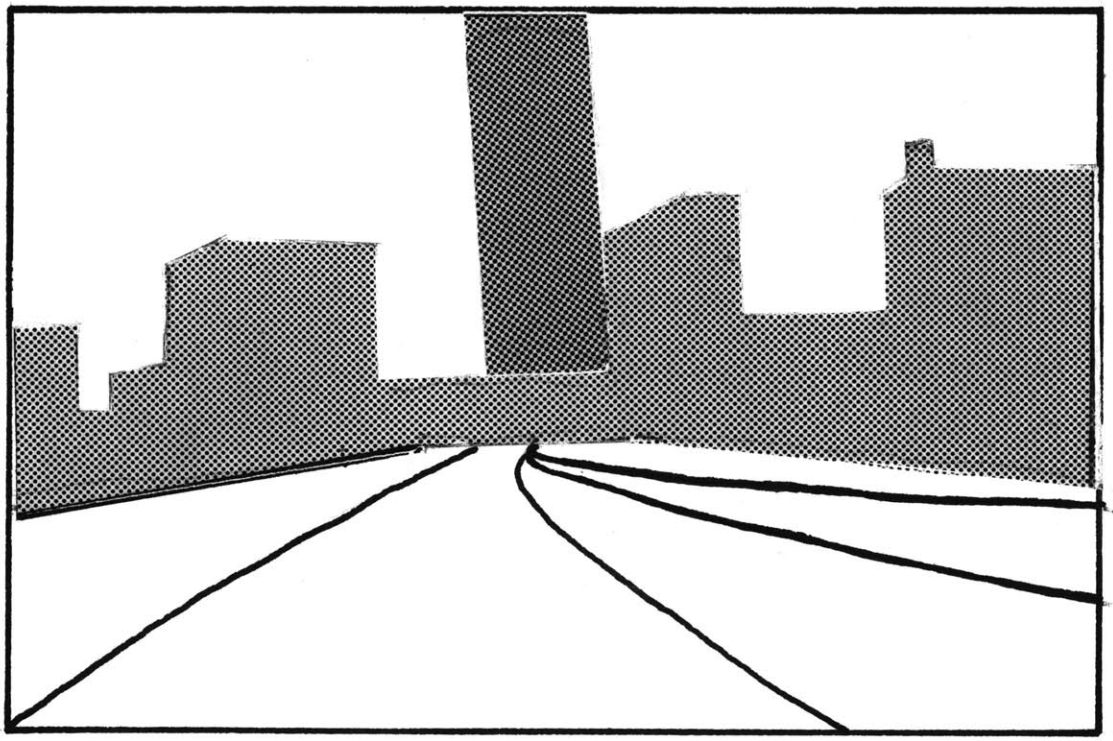
(2) "like Prudential" L

(3) "variety of buildings" L

(4) "something to look at" L

L = liked D = disliked

Scene 10



Group I Group II Group III Group IV

Scene 10 - Change Diagram

SCENE 10

Analysis of Driver Criteria

A. Clarity of road - strong

B. View ahead - moderate, view is cut off by curve.

C. Static reference - poor, road is curved thus entire scene is in motion.

D. Amount of change - high

Analysis of Non-Driver Criteria

A. Variety in skyline - good, four large buildings in middle ground provide interesting composition.

B. Foucus or dominant feature - strong, there is a high level of interest across the entire skyline.

Findings

This was the best liked scene by non-drivers, who voted seven to one in favor of it. Both non-driver criteria were rated as optimum. Drivers, on the other hand, generally disliked this scene voting six to two against it. Because the scene is on a curve, the view ahead is limited, there is no static reference and scene change is high, only clarity of the road was optimum. This scene strongly supports the hypothesis that drivers and non-drivers are using different criteria on judging scenes.

SCENE 6

LIKED - DISLIKED RESPONSES

| | MOVIE | | SLIDES | |
|---|---|---|---|---|
| | Drivers | Non-Drivers | Drivers | Non-Drivers |
| LIKED | 1 | 3 | 0 | 1 |
| DISLIKED | 7 | 5 | 8 | 7 |

Sample Comments on Scene

Drivers watching Movie

| | |
|---|---|
| (1) "going too fast, unsafe" | D |
| (2) "felt on edge" | D |
| (3) "no view ahead" | D |
| (4) "no focus" | D |

Non-Drivers watching Movie

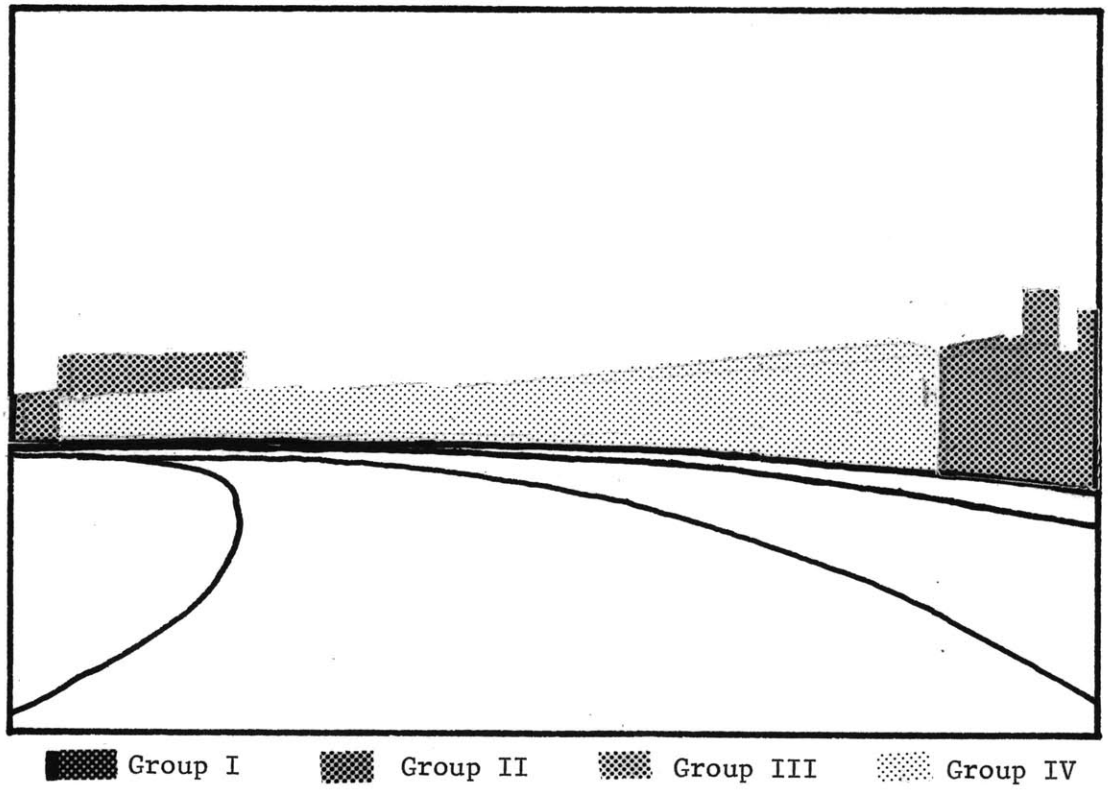
| | |
|---|---|
| (1) "no landscape" | D |
| (2) "nothing of interest" | D |
| (3) "too much train" | D |
| (4) "nice abstract composition" | L |

Drivers and Non-Drivers watching Slides

| | |
|---|---|
| (1) "don't see anything" | D |
| (2) "no interest" | D |
| (3) "nothing to look at" | D |
| (4) "dull" | D |

L = liked  D = disliked

Scene 6




Scene 6 - Change Diagram

SCENE 6

Analysis of Driver Criteria

A. Clarity of road - strong

B. View ahead - very low, due to curve

C. Static reference - low, none

D. Amount of change - very high

Analysis of Non-Driver Criteria

A. Variety in skyline - low, few elements, all of uniform height

B. Focus or dominant feature - low

Findings

Non-drivers voted three to five against this scene and commented on the scene's lack of interest and "repetition". This is consistent with the analysis of non-driver criteria which were both rated low.

Drivers very strongly disliked this scene, voting seven to one against it. In their comments they mentioned "going too fast" and "no view ahead". The criteria of view ahead, static reference and amount of change all received ratings extremely unfavorable to driving. This scene suggests that drivers do value a sense of orientation and that although a scene is simple there is a limit to the amount of change that they can tolerate.

SCENE 25

LIKED - DISLIKED RESPONSES

| | MOVIE | | SLIDES | |
|---|---|---|---|---|
| | Drivers | Non-Drivers | Drivers | Non-Drivers |
| LIKED | 0 | 6 | 5 | 7 |
| DISLIKED | 8 | 2 | 3 | 1 |

Sample Comments on Scene

Drivers watching Movie

(1) "can't see where I am" D

(2) "feel trapped" D

(3) "just hate tunnels" D

(4) "very stressful" D

Non-Drivers watching Movie

(1) "very dramatic" L

(2) "strong composition" L

(3) "simple pattern" L

(4) "no sense of speed" D

Drivers and Non-Drivers watching Slides

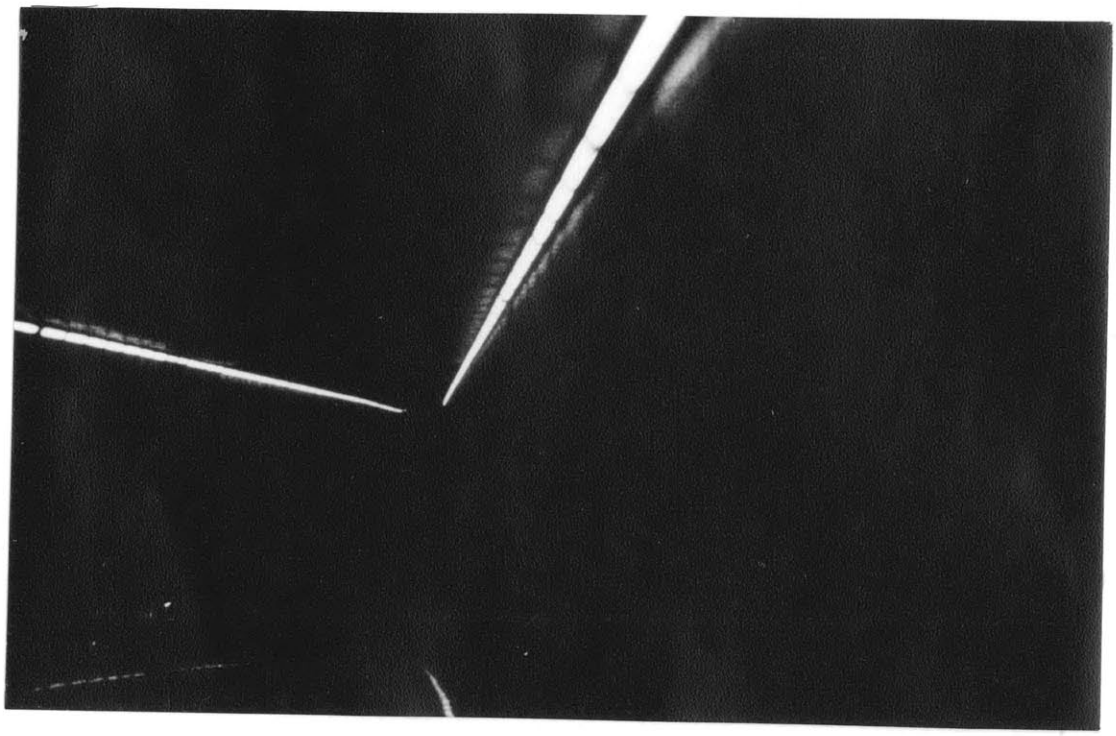
(1) "it's interesting" L

(2) "striking" L

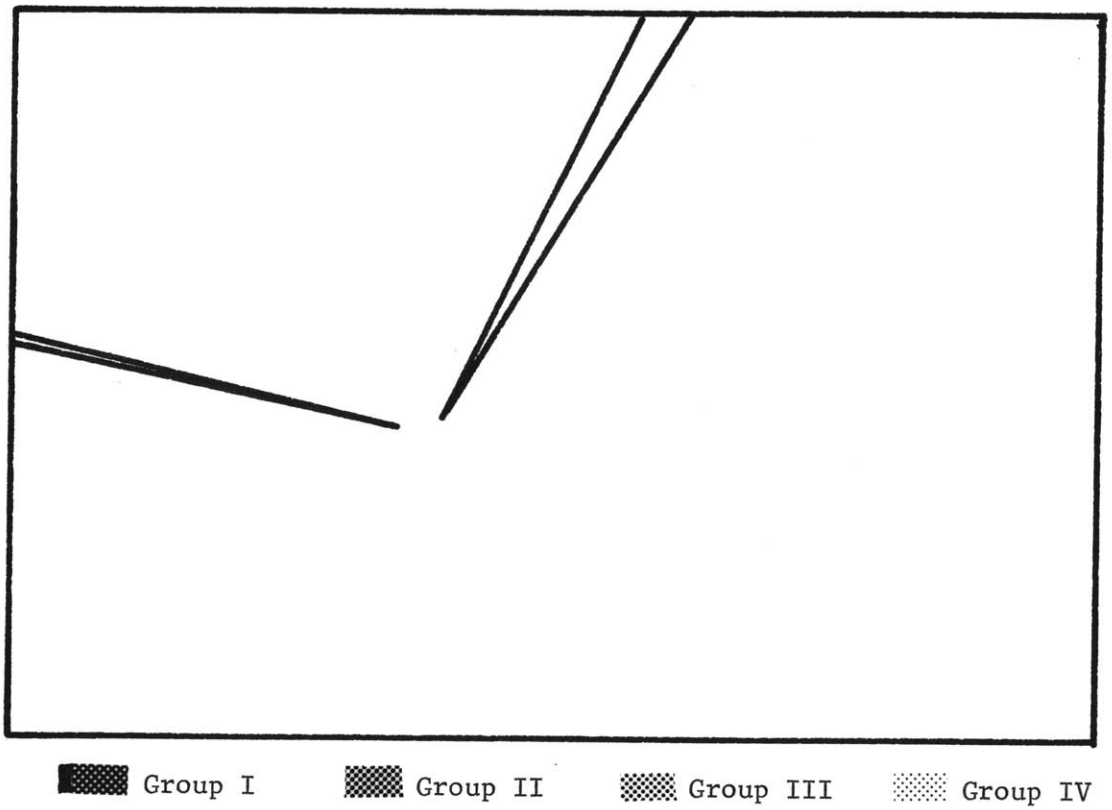
(3) "nice composition" L

(4) "artsy" L

L = liked D = disliked



Scene 25




Scene 25 - Change Diagram

SCENE 25

Analysis of Driver Criteria

A. Clarity of road - none, road is not visible

B. View ahead - low, scene lacks any visible elements.

C. Static reference - moderate, tunnel lights are stable

D. Amount of change - none, because the only visible elements are parrallel to the line of travel.

Analysis of Non-Driver Criteria

A. Variety in skyline - low, none

B. Focus or dominant feature - very strong, light pattern provides very strong abstract pattern.

Findings.

This was an unusual scene and points out a fundamental difference between drivers and non-drivers. Non-drivers generally liked this scene and voted six to 2 in favor of it. They commented on the light pattern and the strong simple composition. The criteria of focus or dominant feature was rated very high. However, all drivers disliked this scene. They felt very uneasy and complained of being lost and trapped. Although drivers knew that they were moving in the scene, there was a complete lack of clues about location and speed.

SCENE 13

LIKED - DISLIKED RESPONSES

| | MOVIE | | SLIDES | |
|---|---|---|---|---|
| | Drivers | Non-Drivers | Drivers | Non-Drivers |
| LIKED | 2 | 6 | 5 | 6 |
| DISLIKED | 6 | 2 | 3 | 2 |

Sample Comments on Scene

Drivers watching Movie

(1) "you can see end of tunnel, but still hate" D

(2) "stressful, but lights help" D

(3) "open at end" D

(4) "not as stressful as before" D

Non-Drivers watching Movie

(1) "nice pattern" L

(2) "stimulating" L

(3) "fun" L

(4) "dull" D

Drivers and Non-Drivers watching Slides

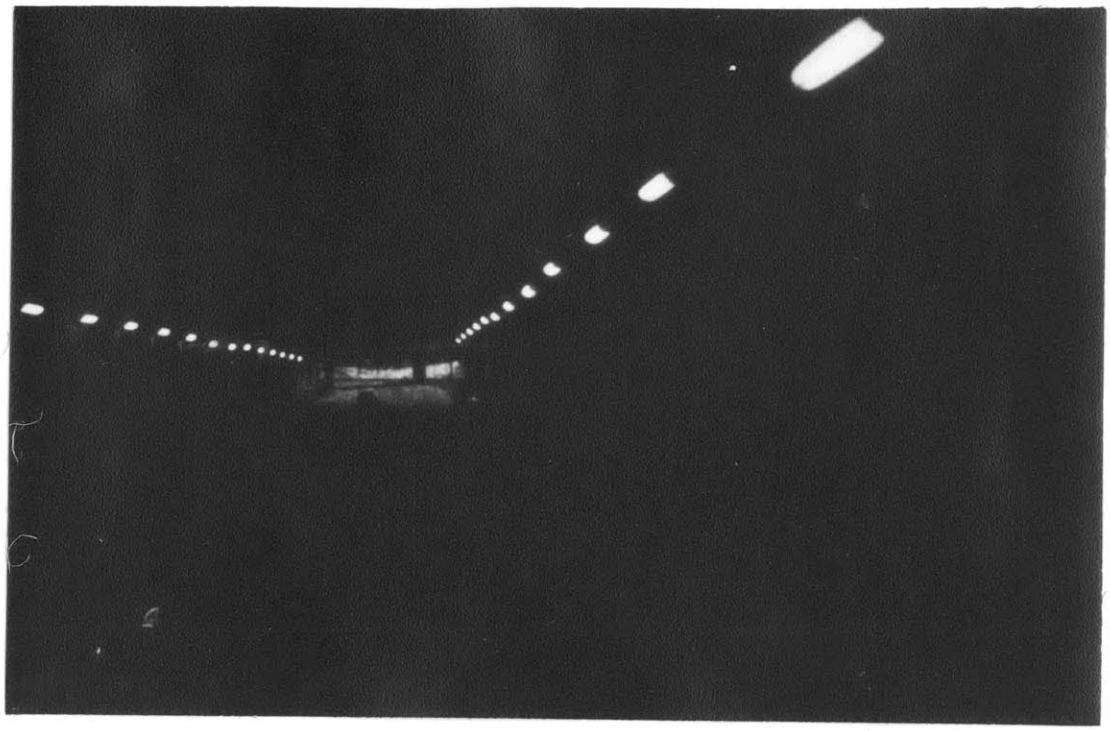
(1) "strong focus" D

(2) "like light patterns" L

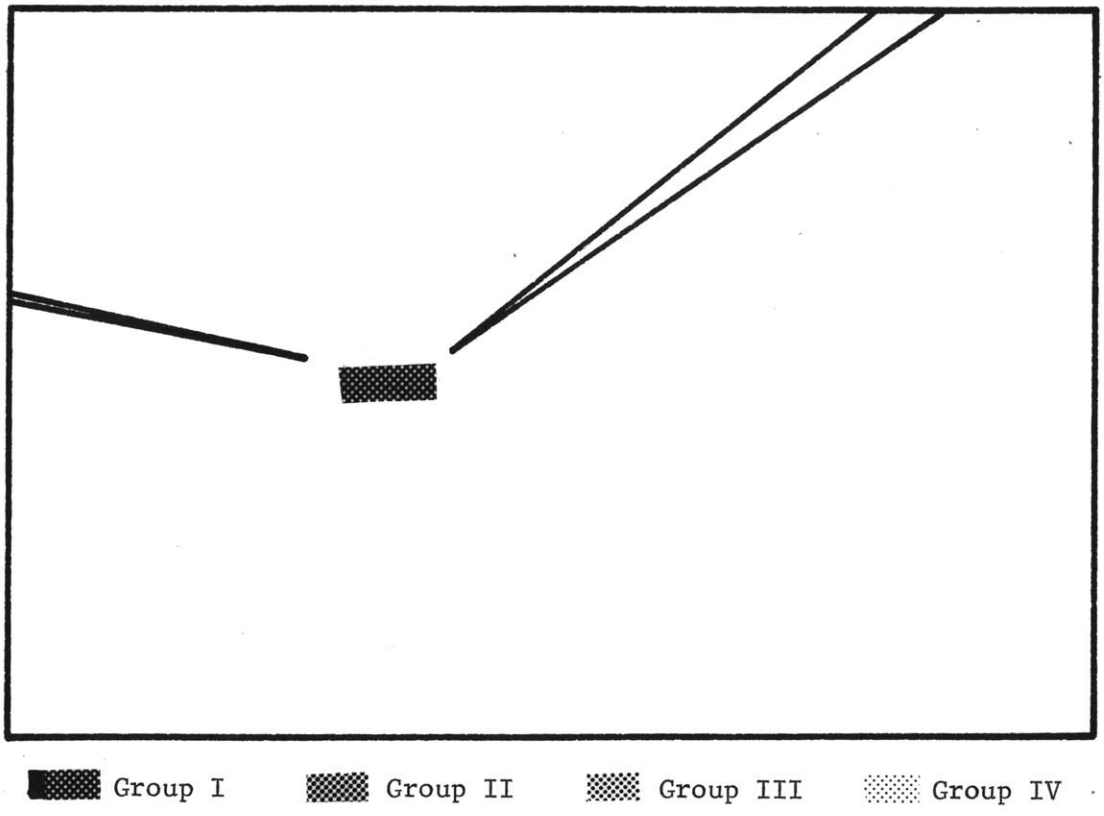
(3) "exciting" L

(4) "compositon very nice" L

L = liked D - disliked



Scene 13




Scene 13 - Change Diagram

SCENE 13

Analysis of Driver Criteria

A. Clarity of road - none, road is not visible

B. View ahead - good, but very limited

C. Static reference - strong, scene beyond tunnel is small enough to be considered a single element

D. Amount of change - low, only the lights give a clue to speed

Analysis of Non-Driver Criteria

A. Variety in skyline - none

B. Focus or dominant feature - strong

Findings

It is interesting to compare this tunnel scene with Scene 25. The two scenes are identical except that this scene has the end of the tunnel visible in the distance and the tunnel lights are individual instead of continuous. Non-drivers still liked this scene and the analysis of non-driver criteria remained the same. Drivers did not feel as strongly against this scene as they had against Scene 25, voting only six to two against it rather than eight to zero. Their comments suggest that the end of the tunnel gave a sense of orientation and promised relief from the tight confinement. The individual lights gave a sense of speed. This scene, in conjunction with Scene 25 supports the driver criteria.

SCENE 14

LIKED - DISLIKED RESPONSES

| | MOVIE | | SLIDES | |
|---|---|---|---|---|
| | Drivers | Non-Drivers | Drivers | Non-Drivers |
| LIKED | 1 | 0 | 1 | 2 |
| DISLIKED | 7 | 8 | 7 | 6 |

Sample Comments on Scene

Drivers watching Movie

(1) "can't see ahead" D

(2) "approaching abutment" D

(3) "bridge blocks view" D

(4) "a little peek beyond, but" D

Non-Drivers watching Movie

(1) "too much concrete" D

(2) "nothing to look at" D

(3) "uninteresting" D

(4) "dull" D

Drivers and Non-Drivers watching Slides

(1) "flat" D

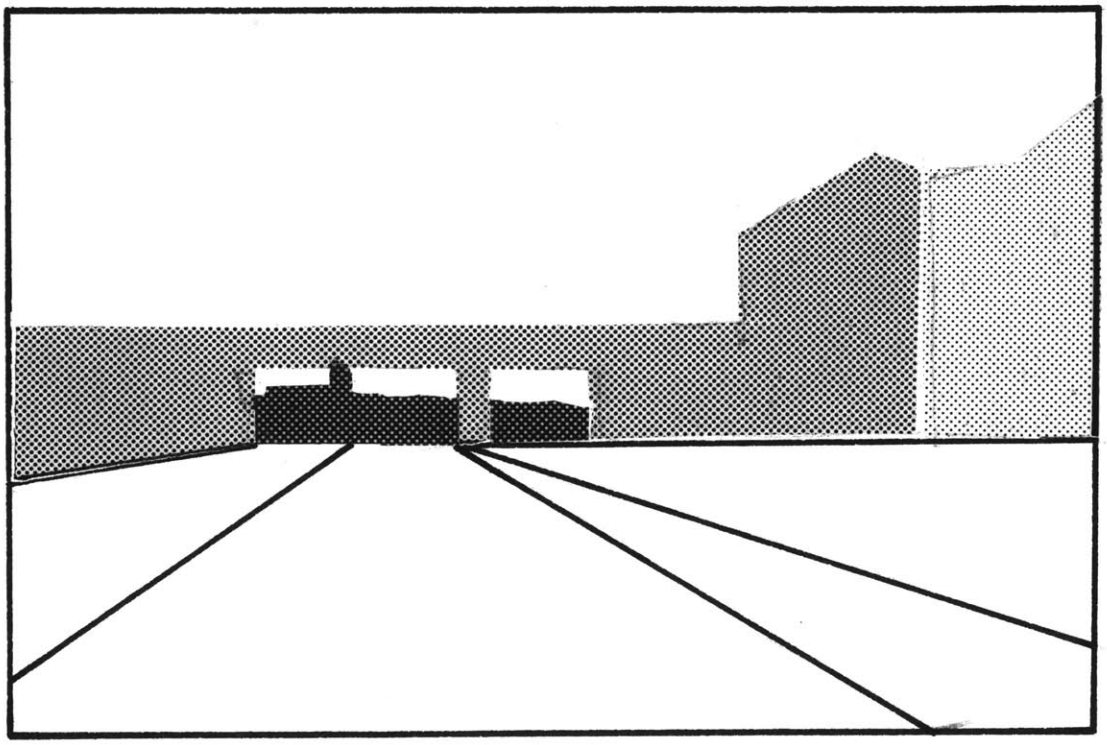
(2) "undistinguished" D

(3) "hate overpass" D

(4) "like Bronx" D

L = liked D - disliked

Scene 14




Scene 14 - Change Diagram

SCENE 14

Analysis of Driver Criteria

A. Clarity of road - strong

B. View ahead - moderate, limited by overpass

C. Static reference - moderate, the area of Group I at the end of the road is not dominant

D. Amount of change - high, much of the scene is in Groups III and IV

Analysis of Non-Driver Criteria

A. Variety in the skyline - low

B. Focus or dominant feature - low

Findings

This scene presents an overpass in the middleground and was the most disliked of all the scenes. Non-drivers commented about the dull composition produced by the road, sky, overpass and buildings. Both non-driver criteria were rated low.

Drivers also disliked this scene, voting seven to one against it, but commented more about the blocked view ahead and fear of the approaching abuttment. Three of the driver criteria were rated unfavorable to the driving task.

SCENE 17

LIKED - DISLIKED RESPONSES

| | MOVIE | | SLIDES | |
|---|---|---|---|---|
| | Drivers | Non-Drivers | Drivers | Non-Drivers |
| LIKED | 3 | 7 | 7 | 8 |
| DISLIKED | 5 | 1 | 1 | 0 |

Sample Comments to Scene

Drivers watching Movie

(1) "bursting out" D

(2) "great sense of anticipation" L

(3) "couldn't see well" D

(4) "disliked, but relief is coming" D

Non-Drivers watching Movie

(1) "scene framed" L

(2) "contrast is striking" L

(3) "nice composition" L

(4) "good scene ahead" L

Drivers and Non-Drivers watching Slides

(1) "nice composition" L

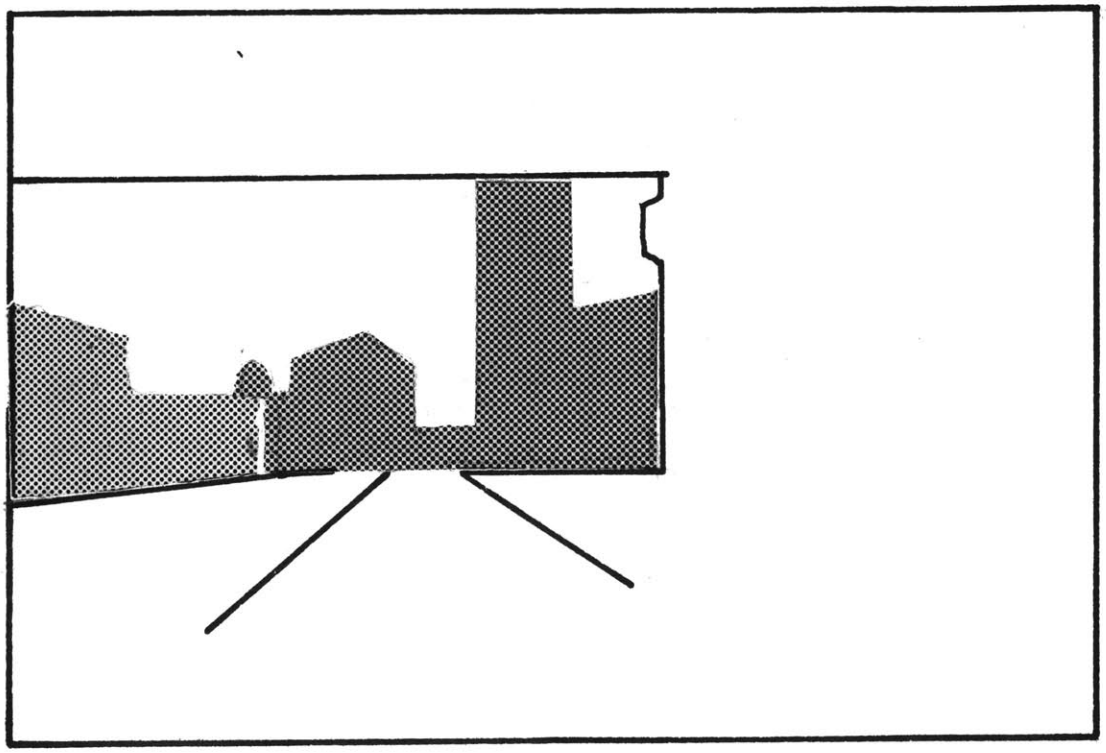
(2) "interesting" L

(3) "very dramatic" L

(4) "contrast of light and dark" L

L = liked D = disliked

Scene 17




Scene 17 - Change Diagram

SCENE 17

Analysis of Driver Criteria

A. Clarity of road - low, road edge is not visible in foreground

B. View ahead - good

C. Static reference - moderate

D. Amount of change - very high

Analysis of Non-Driver Criteria

A. Variety in the skyline - good

B. Focus or dominant feature - moderate

Findings

Several scenes were just emerging from overpasses or tunnels. Non-drivers commented about the framing effect of the overpass edges, an effect they apparently found dramatic. Non-drivers generally judged these scenes on the basis of the view beyond. In this case, they voted seven to one in favor of the scene. The criterion, variety in the skyline was rated good, and focus or dominant feature was rated moderate. Drivers on the other had, uniformly disliked this type of scene much like they had uniformly disliked the tunnel scenes. The analysis reveals that clarity of the road was always very low and change was always very high in this type of scene.

In summary, Chart IV shows the ratings of scene criteria compared to the liked-disliked responses.

CHART IV

ANALYSIS RATINGS

| RESPONSES | DRIVER CRITERIA | | | | NON-DRIVER CRITERIA | |
|---|---|---|---|---|---|---|
| liked-to-disliked | A | B | C | D | A | B |
| 8 to 0 | | | | | | |
| Scene 4 | (+) | (+) | (+) | (0) | | |
| 7 to 1 | | | | | | |
| Scene 8 | (+) | (+) | 0 | (0) | | |
| Scene 10 | | | | | (+) | (+) |
| Scene 17 | | | | | (+) | 0 |
| 6 to 2 | | | | | | |
| Scene 4 | | | | | 0 | (+) |
| Scene 25 | | | | | - | (+) |
| Scene 13 | | | | | - | (+) |
| 5 to 3 | | | | | | |
| Scene 8 | | | | | 0 | 0 |
| 4 to 4 | (+) | (+) | - | - | | |
| 3 to 5 | | | | | | |
| Scene 17 | - | (+) | 0 | + | | |
| Scene 6 | | | | | - | - |
| Scene 22 | | | | | - | - |
| 2 to 6 | | | | | | |
| Scene 10 | (+) | 0 | - | + | | |
| Scene 26 | - | 0 | (+) | - | | |
| 1 to 7 | | | | | | |
| Scene 6 | (+) | - | - | + | | |
| Scene 14 | (+) | 0 | 0 | + | | |
| 0 to 8 | | | | | | |
| Scene 25 | - | - | - | - | | |
| Scene 14 | | | | | - | - |

+ = high, strong, or good rating
0 = moderate rating
- = low, weak or poor rating

Symbols in parentheses represent optimum ratings.

In general, the subjects'responses and comments were consistent with the analyses and support the criteria and hypotheses put forth. Seven of the nine scenes showed a difference between driver and non-driver responses and support the notion that drivers and non-drivers are using different criteria in judging scenes.

(1) Analysis of these scenes, reinforced by subject comments, support Hypotheses 1 and 4 that drivers are conditioned to attend to visual change while non-drivers attend to composition.

(2) The tunnel scenes strongly supported the Hypothesis 2 that drivers rely on road-related elements.

(3) The scenes, taken collectively, support Hypothesis 3 that drivers prefer scenes that provide:

a. strong road definition

b. a good view ahead

c. a static reference

d. some, as yet undefined, optimal amount of change

(4) The scenes, taken collectively, also support Hypothesis 5 that non-drivers prefer scenes that provide:

a. a variety in the skyline

b. a focus or dominant element

Further Work

This investigation has suggested that drivers are influenced

more by relationships between themselves and road-related elements than by the relationships between the elements. If this is true, then the traditional concepts of physical design, used in highway design, concepts that revolve at least in part around the relationships of one element to another, should be altered or perhaps even abandoned in favor of new criteria based on visual change. Conceivably, designs based on such criteria might appear intelligible or pleasing only when viewed while in motion much like the frames of a movie only make real sense when seen in rapid succession. Further study is necessary to determine what forms such designs might take.

There appear to be two logical approaches that future work could follow. The first would be to attempt to verify the ideas presented in this study through real driving situations, thereby proving what can now be only assumed. The other approach would be to search for known perceptual and physiological processes that might be relevant to highway perception and the driving task. Along the lines of this second approach, a library search was conducted to find what information was available that might be useful in this type of study. Part II presents this information.

## PART II - VISUAL ACUITY

### Static Acuity

Man's visual field extends about 180° horizontally and about 145° vertically. The eye however, does not see equally well throughout the entire field. The retina is covered with two types of light sensory devices: cones and rods. The cones are responsible for vision in bright illumination and color recognition; the rods handle vision in lower illumination. The central most two degrees of the retina is called the fovea, and because of the high concentration of cones in this area vision is best here. When both observer and object are still, the smallest detail that the average person can resolve in the fovea subtends an angle of about two minutes of arc.[1] This angle, called the angle of critical detail, allows you to thread a needle at close range, but requires that a letter be three and one-half inches high to be read at 1,000 feet.[2] There is a sharp decrease in the density of cones outside the fovea which produces a correspondingly rapid increase in the size of the smallest detail that can be seen. Chart I shows how the angle of critical detail varies throughout the visual field.[3]

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[1] Webb, P., (27) p. 321. Number in parentheses refers to item in Bibliography.

[2] Tunnard, C., (26) p. 171.

[3] Webb, P., (27) p. 323.

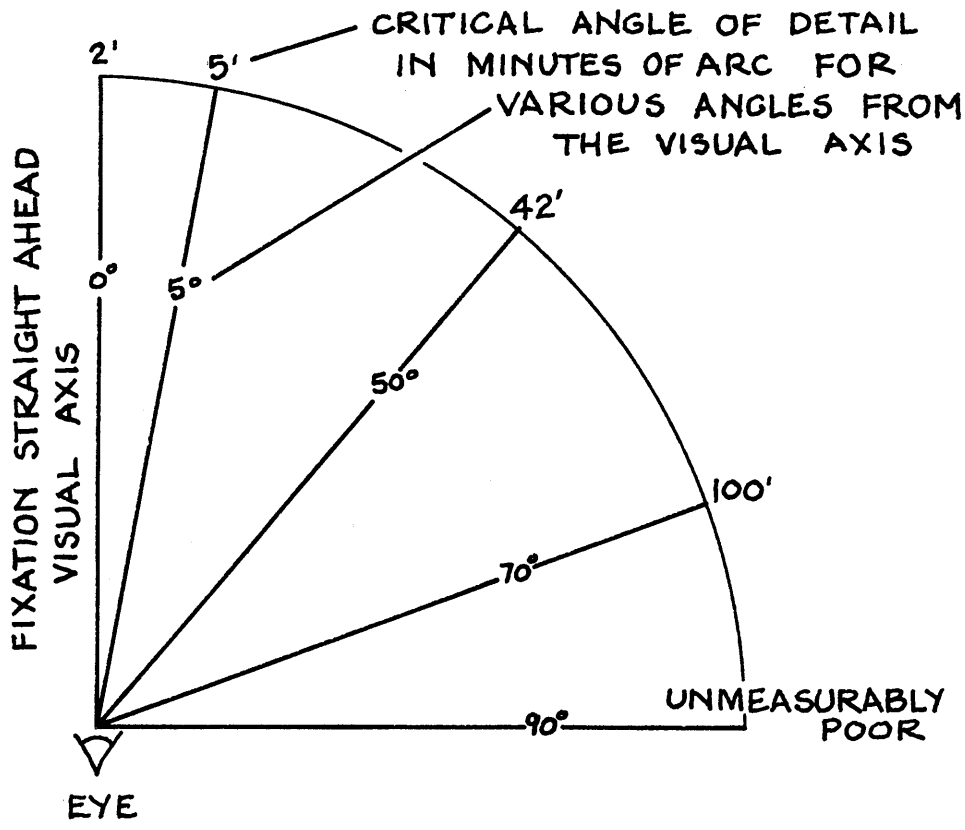


Chart I
Static Acuity

Dynamic Acuity

The effect of motion, either of the subject or the observer, is to increase the angle of critical detail and thus increase the size of the smallest object that can be seen. Psychologists refer to this as dynamic visual acuity. E. J. Ludvigh, working with Navy Pilots found that motion effects acuity as illustrated below.[4]

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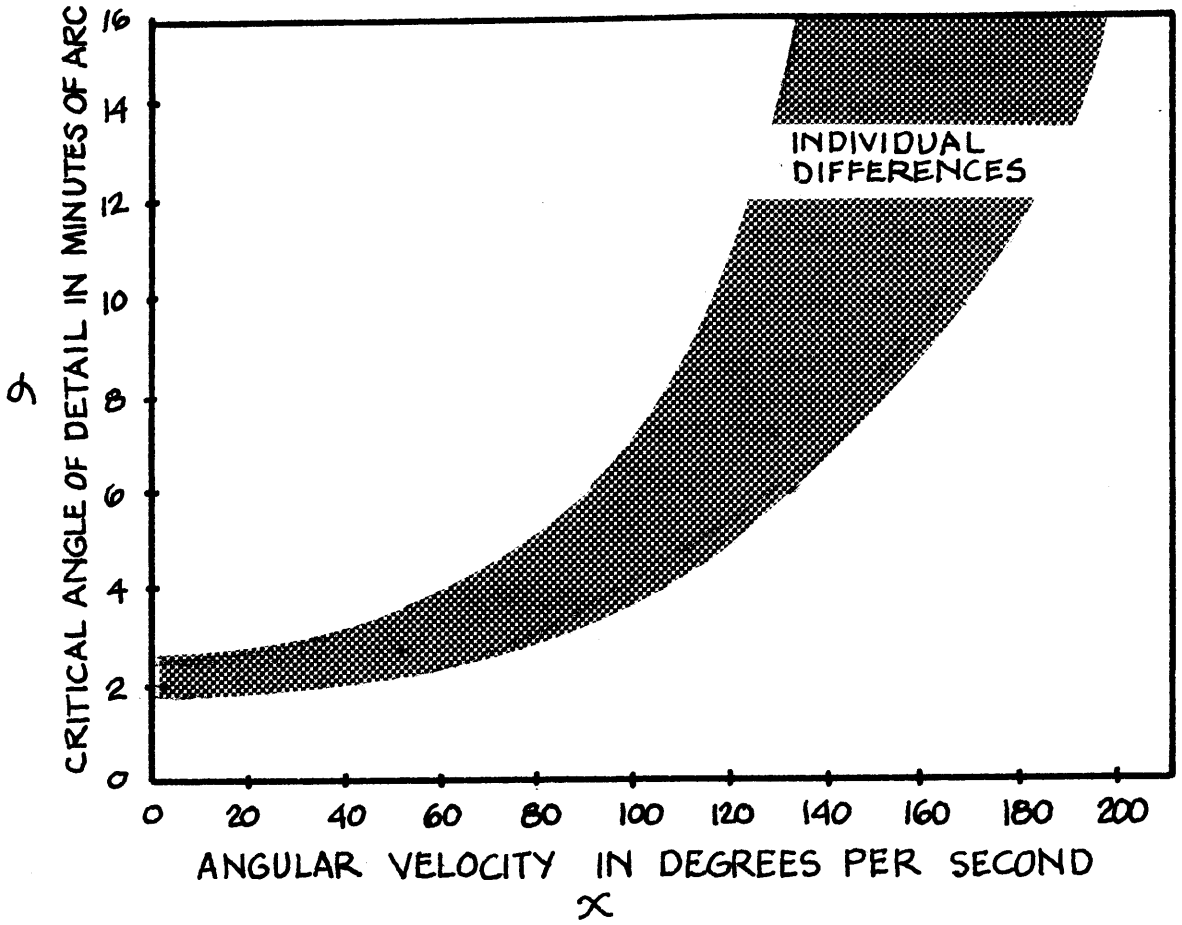
[4] Ludvigh, E., (16).




The angular velocity is the angle subtended by the movement at the observer's eye per unit of time.

Chart II
Dynamic Acuity

From his data, Ludvigh produced the following equation: [5]

$$\delta = S + Dx^3$$

$\delta$ equals the angle of minimum acuity, $S$ is a measure of static acuity, $D$ is a measure of dynamic acuity and $x$ is the angular velocity. The expression approximates $\delta = S$ for very slow velocities in which case $\delta$ and S have very small values. For large angular velocities $\delta$ is chiefly a function of the term $Dx^3$.

---

[5] Ludvigh, E., (16) p. 3.

An approximation of how an increase in the angle of critical detail appears can be made by comparing Charts I and II. For example, from Chart II we read that for an angular velocity of 100 degrees per second an average individual's angle of critical detail rises to five minutes of arc. Chart I indicates that an acuity of five minutes of arc is similar to static acuity at about ten degrees from the visual axis.

Factors Affecting the Perception of Motion

Thus far, the perception of motion has been thought of as a direct response to real motion. However, J. F. Brown, working in the 1920's found that the perception of motion "follows dynamic laws that are not immediately deducible from the velocity of the stimulus as physically defined." The following list summarizes those factors which Brown found to cause the perceived velocity to differ from the real velocity.[6]

A. As the distance between the observer and the moving field increases, the observer will perceive a phenomenal decrease in velocity.

B. An increase in the heterogeneity of the moving field will increase the phenomenal velocity.

C. An increase in the size of the field will decrease the phenomenal velocity.

---

[6] Brown, J. F., (4) pp. 99-101.

D. An increase in the size of the moving object will decrease the phenomenal velocity.

E. Objects oriented parallel to the direction of movement will appear as moving faster than objects oriented perpendicular to the line of movement.

F. Vertical movements will appear faster than horizontal movements and diagonal movements will fall between the two.

G. A decrease in illumination will increase the phenomenal velocity.

H. A decrease in contrast between object and field will produce an increase in the phenomenal velocity.

I. Motion observed while fixating will appear faster than during eye pursuit.

J. Motion seen with foveal vision will appear faster than motion seen peripherially.

From Brown's list it is clear that the perception of motion in the highway will be dependent on a large matrix of factors. Unfortunately, no further work has been done in this area, but Brown's factors should be kept in mind as potentially altering the perception of any highway situation.

## VISUAL CHANGE IN THE HIGHWAY ENVIRONMENT

The amount of change in the highway environment can be described mathematically.

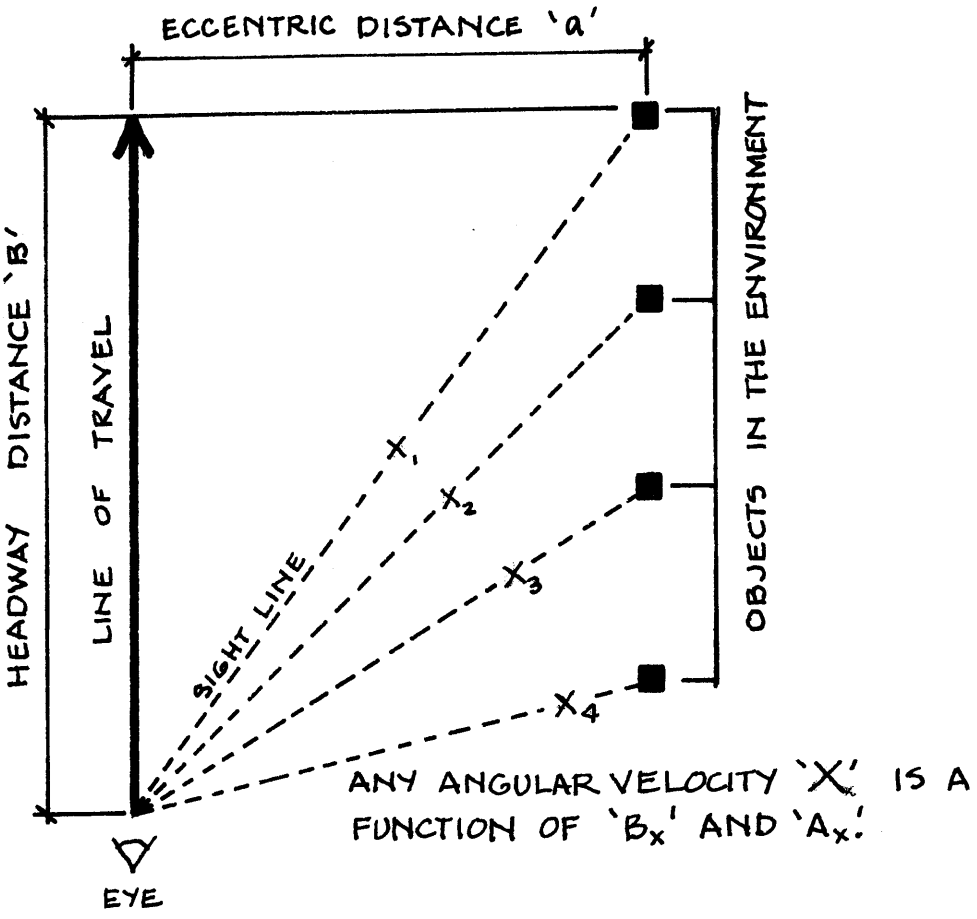



Chart III
Change in the Highway Environment

The angular velocity of any object at any instant can be formulated as:

$$\text{ANGULAR VELOCITY 'X'} = \frac{A}{A^2+B^2}\ SC$$

'b' is the headway distance between driver and object, 'a' is the perpendicular distance the object is offset from the line of travel, 'S' is the speed of travel and 'C' is a constant used to adjust the units. This equation is applicable to all modes of travel and all speeds.

The diagram below illustrates how the equation operates. The highway is typical and travel is at 60 MPH.

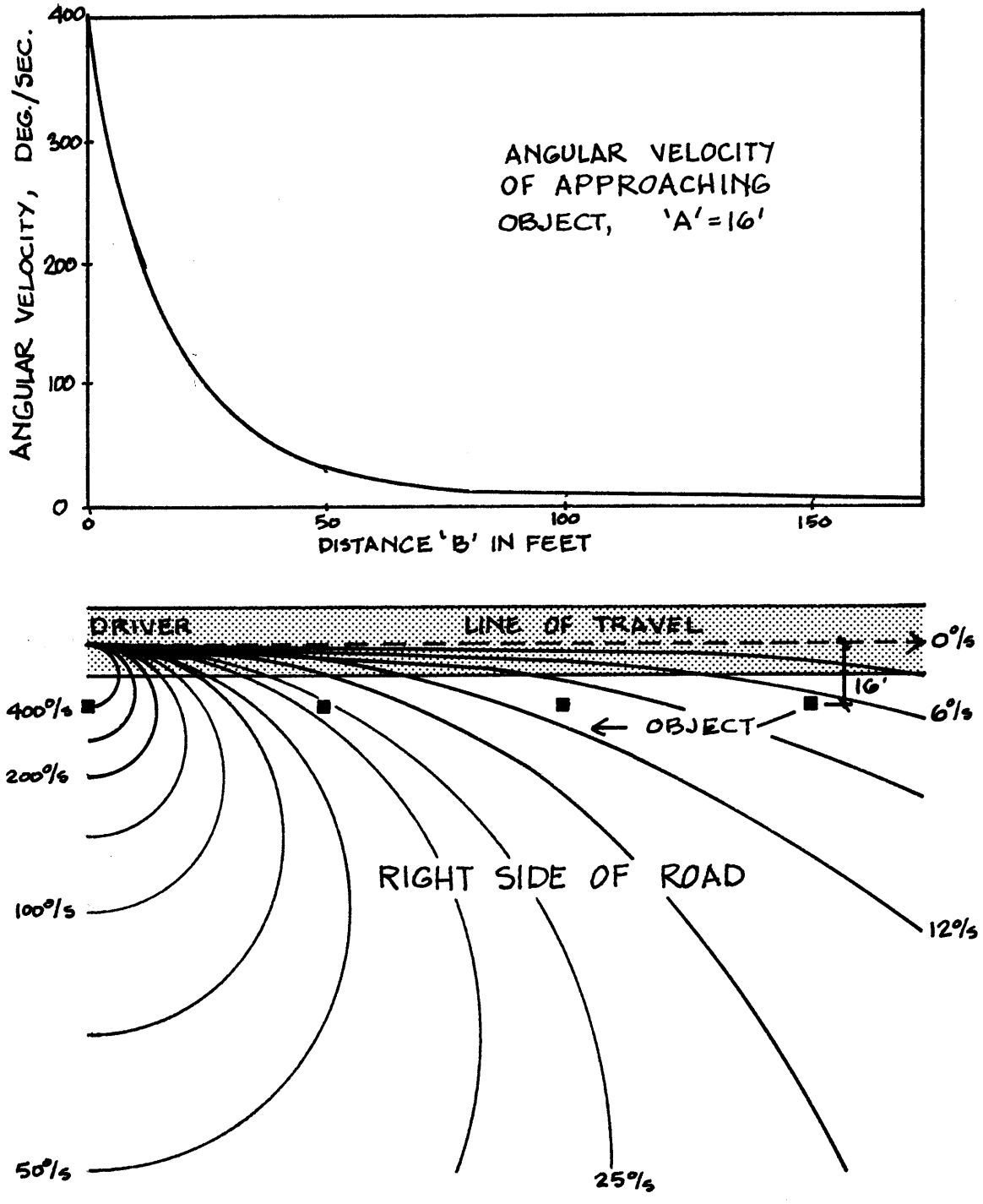



Chart IV
Angular Velocities in the Highway Environment

Using Ludvigh's data from Chart II, Chart IV can be redrawn to illustrate the loss of visual acuity in the driver's visual field.

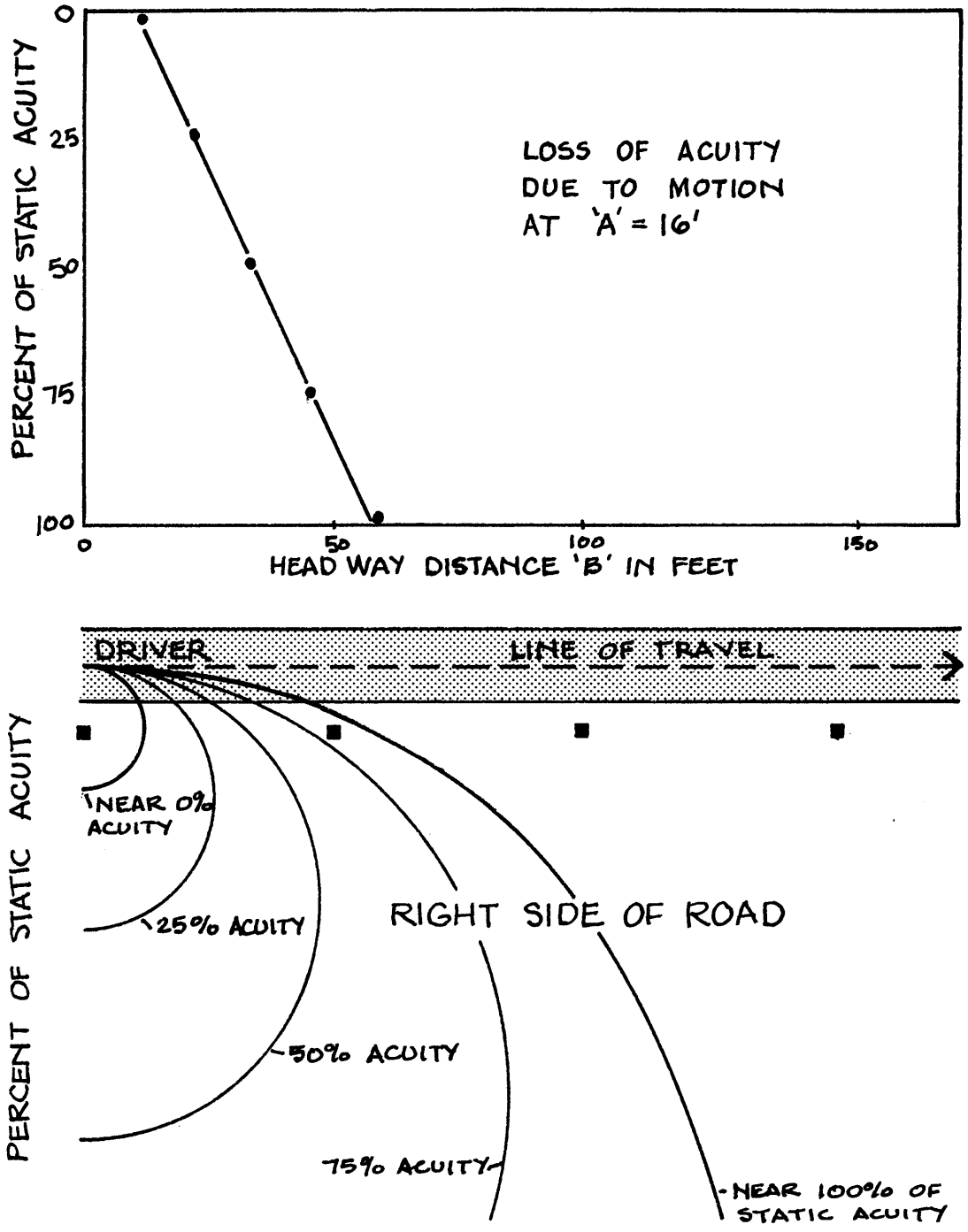



Chart V
Acuity in the Highway Environment

Four Types of Perceived Motion

From our everyday experience, we can define four significantly different types of visual motion in the highway environment. The first type, State I, exists when the motion is too slow for us to perceive as motion, yet over time we can recognize a displacement. The view of a distant landmark or the hands of a clock are examples of this first situation. As motion speeds up, we enter State II, in which motion is perceivable, but slow enough that objects can be identified and signs read. State III is commonly called blur. Specifically, it occurs when the contour between the object and background breaks down. A fence close to the road that flickers as you drive by is in State III. State IV occurs when motion is so fast that we do not see the object at all.

Referring again to Chart II: Ludvigh found that slow velocities had little effect on acuity and thus we might predict that the threshold for perceived motion (State I to State II) would be about the same as the angle for critical detail (two minutes per second). Also State III (blur) would occur when the angle of critical detail equals the angle subtended by the object. Furthermore, Ludvigh's function for dynamic acuity ( $D\alpha^3$) becomes asymptotical for large velocities and this indicates that there is perhaps some absolute limit for dynamic acuity beyond which nothing can be seen - State IV.

Thus object size, the angle the object subtends with the eye, and its angular velocity all contribute to determine which state an object

will be in. A change in any one of these three variables can move the object from one state to another. Chart VI below illustrates how objects of the same size, always subtending the same visual angle but having different angular velocities can appear in all four States.

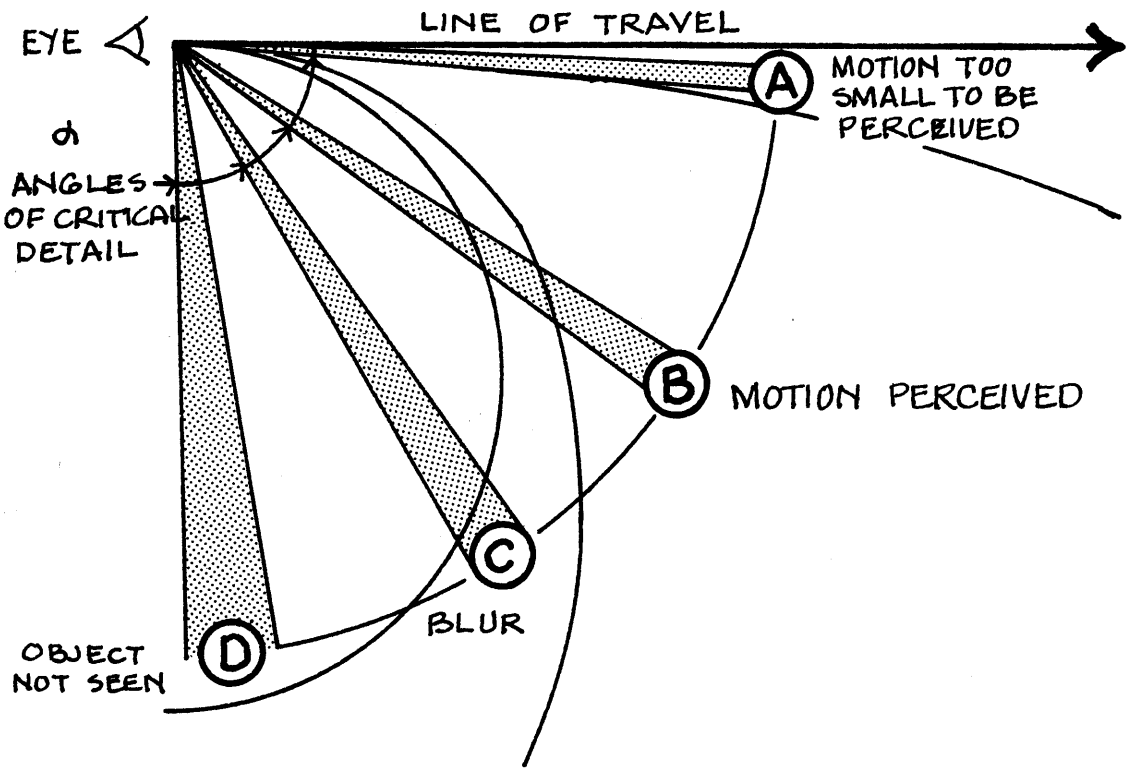



Chart VI
Four States of Visual Movement

Object A, because its angular velocity is less than the minimum angle for perceived movement is in State I and the driver's acuity is similar to his static acuity. Object B is in State II: it is perceived in motion and is readable. Object C is in State III: the

angle it subtends equals the angle of critical detail for its angular velocity. Its contours are breaking down, it appears blurred. Object D is in State IV: the angle of critical detail for its angular velocity exceeds the angle it subtends and it is not seen at all.

It is important to remember that the factors sighted by Brown phenomenally alter the perception of velocity and therefore shift the thresholds between the various States. For example, Object C is in State III (blur) at a given illumination. If the illumination is increased, Object C will have a phenomenally lower velocity, enough perhaps to drop it back into State II (moving, but not blurred) along with Object B.

## THE DRIVING TASK

How does the driver use the information contained in the highway environment? The driving task can be looked at as a series of short trips, each perhaps not more than a second or more in length. The driver looks ahead and from the view extracts a 'field of safe travel'; the length of road ahead that he will soon occupy. He also conceptualizes a 'minimum control zone' based on his ability to bring his vehicle to a controlled stop. He then compares these two judgments. The first, the 'field of safe travel' must be greater than the second, 'the minimum control zone' for the driver to be safe. The difference between the two is the amount of risk the driver is willing to take.[7]

Every driver is aware that in many situations he does not have to concentrate on the road all the time. He looks off the road, at the instruments, he talks, listens to the radio. With periodic short glances, he can perceive the necessary field of safe travel. During the remainder of the time, he can turn his attention to other things, in a sense, drive blind until he has used up his field or forgotten what it looks like. He must then repeat the process; take another trip.

The amount of time spent looking ahead versus looking elsewhere is a function of the amount of change or chance of change (uncertainty)

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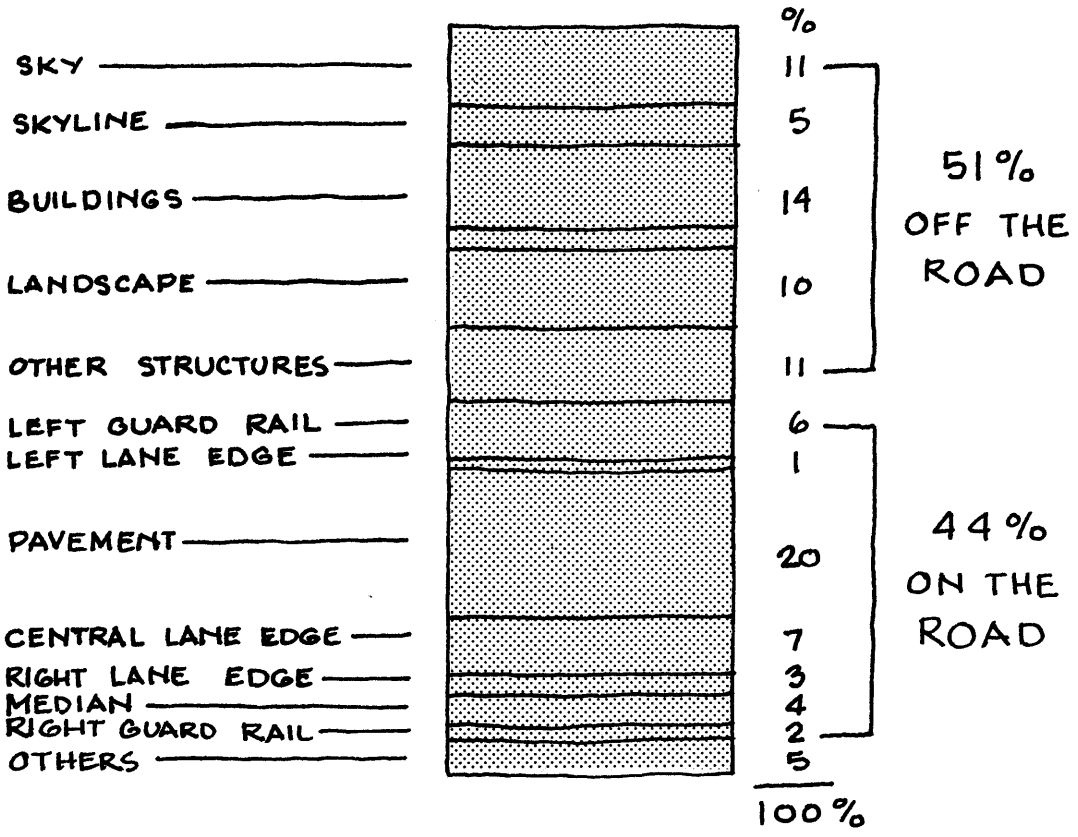
[7] Schesinger, L. E., (19) p.55.

that lies ahead. A recent Japanese study reveals how one urban driver divided his time between looking at the road and at other things. The chart below shows the percentage of eye fixations that fell on various portions of the highway scene during a short trip. The exact circumstances of the study are not know, but from other comments in the report, it can be assumed that there was light traffic. In interpreting 'on the road' date, it should be remembered that the Japanese drive on the left side of the road similar to the English.[8]




In this case, the driver was attentive to the road only half of the time.

Chart VII
Distribution of Driver Fixations

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[8] Suzuki, C., (21) p.27.

This search, although necessarily superficial, points out that there is much that can be learned from indirect sources. At present, the problem is to link one study to another. This author suggests that possibly a solution lies in combining theories of perception and the driving task with data from field tests in a mathematical statement, perhaps a model. Such a system would have the advantage of being able to express known or hypothesized relationships without having to define all of the variables. New data could be added as it became available. Also, such equations could be manipulated to suggest new relationships or areas of investigation.

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