ABSOLUTE PITCH TRAINING

by

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ABSTRACT

ABSOLUTE PITCH TRAINING

Adopting the training method suggested by Cuddy (JASA, "Practice Effects in the Absolute Judgment of Pitch," 43, 1069-1076, 1968) and successfully employed by Brady (JASA, "Fixed-Scale Mechanism of Absolute Pitch," 45, 883-887, 1970) I have attempted to acquire absolute pitch (that is, absolute identification of musical tones). The teaching method involves basically the memorization of one frequency which is then used mentally for comparison in all absolute pitch judgments. Training involved two steps:

1). Relative pitch training to improve interval recognition.

2). Memorization of the tone C=523 Hz.

My sense of absolute pitch has not been developed to a demonstrative level at this time, however, my performance on all tests has improved over time and hopefully will continue to do so as nothing has indicated that I will be less successful than Cuddy's subjects or Brady.

Although a great deal of time has been devoted to this training over a 15 month period, I can only conclude that more concentrated (i.e. daily) training is needed, especially on the C memorization which was only begun in the last three months.

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INTRODUCTION

Absolute pitch is the ability to recognize a tone's musical name without the use of a reference tone. Relative pitch is the ability to recognize a tone's musical name with the use of a reference tone. Most people have relative pitch. In the most simplest of tasks they can decide which of two tones has the greater frequency; and in the most difficult of tasks, they can name the musical interval outlined by the two tones. On the other hand, however, very few people have absolute pitch.

There are of course a number of different explanations for this phenomena. Simply stated these are:

1) Absolute pitch is an innate gift; either a person is born with it or he is not.[1,2]
2) Absolute pitch is learned during childhood, and can only be learned during childhood; i.e. a sort of "imprinting" mechanism is involved with absolute pitch.[3,4,5]
3) Absolute pitch is learned and can be acquired at any age. However, in adulthood it takes a great deal of time to be acquired.[6,7,8,9,10,11]

Also, among persons who do have absolute pitch there are different levels of performance. Bachem[2] attempted to divide possessors of absolute pitch into three groups based on their abilities to make absolute pitch judgments. These groups he named: 'Pseudo-Absolute Pitch, Quasi-Absolute Pitch, and Genuine Absolute Pitch." Genuine Absolute Pitch is characterized by quick, definite judgments which are not restricted to any one intrument or group of instruments. The other two groups are merely refined relative pitch.

Until very recently the least popular of the three theories of absolute pitch was probably the third one listed above. As early as 1899[6] it was proposed and demonstrated to some extend that absolute pitch was learnable at any age, however not until Brady[12] in 1970 reported his success at aquiring absolute pitch did any of the reports show a complete and retainable mastery of absolute pitch. Even Brady cannot always identify a pitch by name which would tend to put him in Bachem's Quasi-Absolute Pitch group, but he was successful, at age 32, starting with no absolute pitch ability and through training, in acquiring some sense of absolute pitch, as evidenced by a test he administered to himself in which he correctly identified the musical name of 65% of a set of random tones, and identified 97% of the set within a semitone.

Brady used a method suggested by Cuddy[11] for improving absolute pitch judgments. The process basically involves the memorization of one tone which then can be used with one's sense of relative pitch to automatically identify other pitches.

It was my intention to adopt Cuddy's method in view of the success achieved by Brady, and teach myself absolute pitch. My results are reported in this thesis.

I. METHODS

A. SUBJECT

I, the author, male, age 22, was my only subject. My musical experiences include trombone study in the public school system of St. Louis county since the age of 9, and some private study with a professional which amounts to less than a year of weekly lessons over my 13 years of playing the trombone. I have a beginners ability on the guitar, piano, and marimbas. Since entering college I have taken nine courses in music theory and history. However, never was ear training done in any of these courses, or during my prior musical instruction; nor did I initiate any ear training on my own. I personally feel that I have a "bad ear" since I've always found it difficult to tune my guitar or play my trombone in tune with other players. Never was I able to identify musical intervals aurally until I began these experiments, which indicates that this was a lack of training rather than a lack of ability. I noticed at the same time however, that many of my musical acquaintances also had no formal ear training but because of their "good ear" they had good interval recognition and a lack of an intonation problem. Therefore, never would I have thought myself capable of absolute recognition of pitches if I had not read Brady's or Cuddy's article.

B. APPARATUS

All experiments were conducted with the subject seated in an

IAC, model 1200, sound-insulated chamber. Aural presentations were pure sine-waves generated by a Krohn-Hite, model 4031R, oscillator, and were presented binaurally through a set of TDH-39 headphones. Numerically coded feedback, when desired, was given by a two-digit nixie-tube display inside the chamber. Responses were made on a 16-push-button response box, which also had four lamps which could be used to signal the subject. Responses were recorded by a PDP-8L computer, which also generated all random events as well as controlled the oscillators, switches, and feedback device.

C. GENERAL PROCEDURE

Training was done in three phases. PHASE I & II were relative ear-training exercises. PHASE III was Cuddy's "C-training."

Experiments in PHASE I consisted of series of two note intervals. All intervals were an octave or less. In the course of testing certain intervals became easily recognizable while others remained difficult. Difficult intervals were concentrated on as the subject felt the need. At the beginning of PHASE I the subject typically identified 55% of the intervals correct. By the end of PHASE I the subject had improved to 75% correct.

PHASE II differed from PHASE I only in that all presentations began with C=523 Hz. The range of tones heard was therefore in the range C=262 Hz to C=1047. PHASE II was begun when the subject felt that he recognized all intervals equally well and consequently could make no further improvement in his score (75-80% correct), which although not perfect reflects mistakes due to lack of attention, sleepiness, boredom rather than mistakes due to improper recognition of the intervals.

The design of PHASE II was to familiarize the subject with each tone in relation to C=523 Hz. By this procedure not only was further practice afforded on interval recognition but training was already begun on learning the relation between C and the other tones.

PHASE III was based on Cuddy's C-training. The subject was presented with 100 different pitches at one sitting and was asked to make absolute pitch judgments. At the beginning of PHASE III 80% of the pitches presented were C. When the subject was able to identify 95% of the C's correctly the weighting factor controlling the number of C's heard in any set of 100 presentations was lowered by 10%. At this time the subject was being tested at 30% C's. The subject was asked only to identify the tone C, but could make judgments if he so desired on the other pitches. Feedback was given on all tones.

II. EXPERIMENTS

A. PHASE I: RELATIVE PITCH TRAINING

In PHASE I the subject was presented with a two note interval. His task was to identify the number of semits contained in the interval. All intervals were less than one octave (12 semits) but the frequencies of the notes spanned a two octave range from C=262 Hz to C=1047 Hz. The tones were randomly generated by the computer producing both ascending intervals (intervals where the <u>second</u> tone had a greater frequency than the first tone) and descending intervals (intervals where the <u>first</u> tone had a greater frequency than the second tone). The subject heard 100 presentations in one sitting and typically would listen to three or four such groups in a one to two hour session.

The temporal dimension of one presentation is shown in Figure 2a. The exact time durations of one presentation were not designed to be restricting, or was if felt that over the entire period of PHASE I that they needed to remain constant. They were chosen to be comfortable. So, for example, if the subject felt a little rushed on his response time, this period was lengthed. Infinite time was not allowed for response time because responses should have, and did become immediate reactions to the presentations. This attitude was encouraged by a short, but adequate response time.

Responses were recorded by the computer and printed at the end of a run in a 13x13 confusion matrix. Percentage correct was used as a yardstick of progress. Figure 3 shows percent correct verses the days of experimentation. As the graph shows, the subject correctly identified 50-60% of the intervals at the beginning of PHASE I and improved his performance to 75% correct by the end of PHASE I. The confusion matrix in Figure 8 shows the subject's total performance in PHASE I. Notice that in general there are more confusions for the larger intervals than for the smaller intervals.

A more striking example of the subject's improvement are the results of some special training sessions. These were undertaken because the subject felt that certain intervals were more difficult to recognize than others. Prior to the first recorded data point in Figure 3 the subject was given 100 presentations of descending intervals <u>only</u>. He scored 42% correct on this run which is significantly less than his initial performance with mixed intervals. After the last recorded data point in Figure 3 he was given a similar test. This time he scored 74% correct! So, the subject made a great deal of progress on the recognition of descending intervals.

Another group of "before and after" tests shows a similar improvement. In these tests the subject was presented with

50 presentations which were either of two neighboring, descending intervals. The "before" test was given before the first datapoint recorded in Figure 3 and the "after" test was administered after the last data point. The results are shown in Figure 4. The subject had improved in all cases.

PHASE I was ended because of the summer intersession. PHASE II was begun in the fall rather than returning to PHASE I because it was felt that the subject could continue to improve his interval recognition while beginning to concentrate on C=523 Hz. Indeed, this did happen; by the end of PHASE II his interval recognition had improved to typically 80% correct.

B. PHASE II: C INTERVAL TRAINING

In PHASE II the subject was presented with two note intervals. The first tone was always C=523 Hz. The second tone could then be any number of semits above or below this C within one octave. The subject responded by depressing on his response box the number of the button which corresponded to the number of semits in the interval. Therefore, for example, both an ascending major 6th interval (C to A, 9 semits) or a descending major 6th interval (C to E^b, also 9 semits) required the subject to answer by pressing button #9. The subject felt no confusion in the fact that each note had two, possible correct buttons, depending on whether it appeared in an ascending or a descending interval.

Presentations were given in groups of 100. Typically the subject listened to three of the groups in one day. Figure 2b shows the temporal dimensions of one presentation. If the subject desired, in addition to visual feedback, aural feedback was presented: When an interval was incorrectly identified, the interval was repeated. This was found quite useful at first, but later became annoying and consequently was not used. Four small lamps on the response box prepared the subject for each new presentation and signaled him when it was appropriate for his response, as well as signaled the end of the run. Responses were recorded automatically by the computer and printed in a 26x13 confusion matrix. The matrix showed ascending and descending intervals' responses independently thereby accounting for a confusion matrix with twice the columns (responses) as rows (presentations). This was done to help the subject spot intervals which consistently gave him trouble.

Performance is graphed in Figure 5 which shows per-cent correct on any one day verses the days of experimentation. Each dot in Figure 5 does not represent the same number of presentations, since on one day perhaps 300 trials were made whereas on another day only 100 trials were made. It was found however that performance on any one day was fairly self-consistent. For example, data point 'H' shows a score of 63% correct. This actually is an average of three runs of 100 presentations each in which the subject scored 62%,62%, and 64% respectively; data point 'I' (74%) is an average of two runs in which the subject scored 73% and 76% respectively; and, data point 'J' (81%) is the average of three different runs, with scores 84%,82%, and 76%. So, it was felt that performance was, among other factors, a function of the subject's attentiveness for that day. Therefore, the data can be presented fairly on a daily, rather than individual run basis. The subject's total performance is shown in the confusion matrix in Figure 9.

As shown in Figure 5, the subject improved his performance with time. There is a marked improvement after point 'J' where 12 out of 15 days were above 75% (six days above 80%). Prior to 'J' only four out of nine days were above 75% (and none above 80%). Also, point 'V' was recorded on December 6, 1972 while point 'W' was recorded two months later on February 6, 1973, which indicates that there was no loss of learning over the Christmas vacation.

C. PHASE III: CUDDY'S C TRAINING

In PHASE III the subject was presented with 100 tones in one sitting. The exact pitch was randomly selected from a four octave range. Figure 1 shows the exact values used. Before a run was started the subject heard a steady tone, C=262 Hz, to establish the reference tone in his head.

Presentations were 500 msec. in duration followed by a four second (later shortened to three) answer period. Feedback was given for all stimuli; see Figure 2c.

The subject's only required task was to identify the note C when it was presented. This could have been any of the four different C's included in the four octave range of stimuli. The subject could and was encouraged to make pitch judgments of other pitches.

A weighting factor was used to control the number of C's heard in any group of 100 presentations. The subject started his training with 90% of the presentations C's. This was a trivial task, and he usually scored perfectly. The weighting factor was dropped to 80%, and then to 70% with near perfect identification. As the weighting factor continued to drop the subject's performance also dropped. A graph of his performance during the entire period of PHASE III is shown in Figure 6.

Data points in the graph show percentage of C's correctly identified verses the days of experimentation. There were three ways for the subject to incorrectly identify a C:
1) He could not respond to a presented C. (This was a frequent error since the subject was not required to respond to all stimuli.) 2) He could call a note other

than C a C. 3) He could call a C another note. For example, for data point F' the subject was presented with 31 C's among the 100 presentations. He correctly identified 25 of them or 81%, which is the percentage figure graphed in Figure 6. Six of the presented C's slipped by him. In this particular case five went unanswered and one was identified as an F#. He also made two of the errors labeled as type 2 above. After PHASE III had already gotten underway it was decided that it would be a good idea to keep track of these errors to prevent the subject from biasing his answers toward the C button; as an extreme example of what I mean by biasing; if the subject called all the stimuli C's he certainly would score 100% correct on the C identification task, when in actuallity he has made more errors than correct judgments. So in order to penalize the subject for calling other tones C's, a second percent correct was calculated by dividing the number of C's recognized by the number of C's presented <u>plus</u> the number of other tones wrongly identified as C. This would cause his percentage-correct score to drop by an amount somewhat proportional to the number of these errors. These adjusted percentage-correct scores are shown in Figure 7, beginning with data point 'Q'. Comparing Figure 6 with Figure 7 notice that they have the same contour but the values are lower for Figure 7.

III. DISCUSSION

The subject has not acquired a demonstrative level of absolute pitch. Presented with a tone he cannot give its musical letter name, nor can he sing a requested tone. However, his training period has not reached it's logical end. The subject should continue with PHASE III training until the number of C's in 100 presentations are reduced to abaut eight, which is the number of C's that would be presented if they were being randomly chosen rather than weighted. At this writing he is listening to stimuli with a weighting factor of 30%. The fact that he has shown improvement on all identification tasks over time indicates that he would be no less successful than Brady in acquiring absolute pitch.

To insure acquiring absolute pitch, I feel that it is neccessary for the subject to do daily training. Although he was typically able to get eight to ten hours of training in per week, there were always the two days of the week-end when no training was done, and frequently during the week a day would be missed. A rigorous daily schedule would definitely speed things up. The fact that the subject is able to retain C in his head over the short period of time (approximately 10 minutes) required to listen to the 100 presentations in a PHASE III experiment, indicates that he has the ability to remember the note, and that it is a matter of training to expand this length of memory.

III. DISCUSSION (continued)

The subject now has in his possession a pocket size tuning fork which sounds the pitch C=523.3 Hz. This enables him to reinforce his memory of C during the course of the entire day. The usual procedure is to try and sing the tone C before striking the tuning fork, thereby acurately testing his memory of the tone.

IV. CONCLUSION

In conclusion I feel that this subject requires at least a daily schedule of testing to learn absolute pitch. PHASE I and II probably could have been shortened since the subject's ability to identify intervals seemed to level off at 75-80% correct rather quickly in the course of experimentation. Also if more concentration had been given to those intervals which seemed more difficult to identify, as made evident by the confusion matrix, less time would have been devoted to PHASE I and II and consequently there would have been more time available for PHASE III.

This FIGURE shows the exact frequencies presented to the subject in relation to exact tempered-tuning frequencies. Tempered-tuning frequencies could not be used because the oscillators could only generate integral frequencies. Frequencies in PHASE I&II were calculated by taking the integral portion of the equation: $261.63 \times (1.0595)^s$, where 261.63 is the frequency in Hz of C and s is the number of semitones between C and the desired note. Frequencies in PHASE III were calculated by taking the integral portion of the equation: $131 \times (1.0595)^s$, where again 131 is the frequency in Hz of C. In the first two octaves errors are less than one cycle. In the upper two octaves the error becomes greater but is still less than 0.4% of a semitone.

NOTE	PHASE I & II	TEMPERED FREQUENCY	PHASE III
C		130.82 Hz	131 Hz
C#		138.59	138
D		146.83	147
D#		155.56	155
E		164.81	165
F		174.61	174
F#		184.99	185
G		195.99	196
G#		207.65	208
A		220.00	220
A#		233.08	233
B		246.94	247
C	261 Hz	261.63	262
C#	277	277.18	277
D	293	293.66	294
D#	311	311.13	311
E	329	329.63	330
F	349	349.23	349
F#	370	369.99	370
G	392	391.99	392
G#	415	415.31	416
A	440	440.00	440
A#	466	466.16	467
B	494	493.88	494

FIG. 1

FIGURE 1 (continued)

NOTE	PHASE I & II	TEMPERED FREQUENCY	PHASE III
C	523 Hz	523.26	524
C#	554	554.36	555
D	587	587.32	588
D#	622	622.26	623
E	659	659.26	660
F	698	698.46	700
F#	740	739.98	741
G	784	783.98	785
G#	831	830.62	832
A	880	880.00	882
A#	933	932.32	934
B	988	987.76	990
C	1047	1046.50	1049
C#		1108.72	1111
D		1174.64	1177
D#		1244.52	1247
E		1318.52	1322
F		1396.92	1400
F#		1479.96	1484
G		1567.96	1572
G#		1661.24	1666
A		1760.00	1765
A#		1864.64	1870
B		1975.52	1981

FIG. 1

TEMPRAL DIMENSIONS OF PHASE I, II, & III EXPERIMENTS

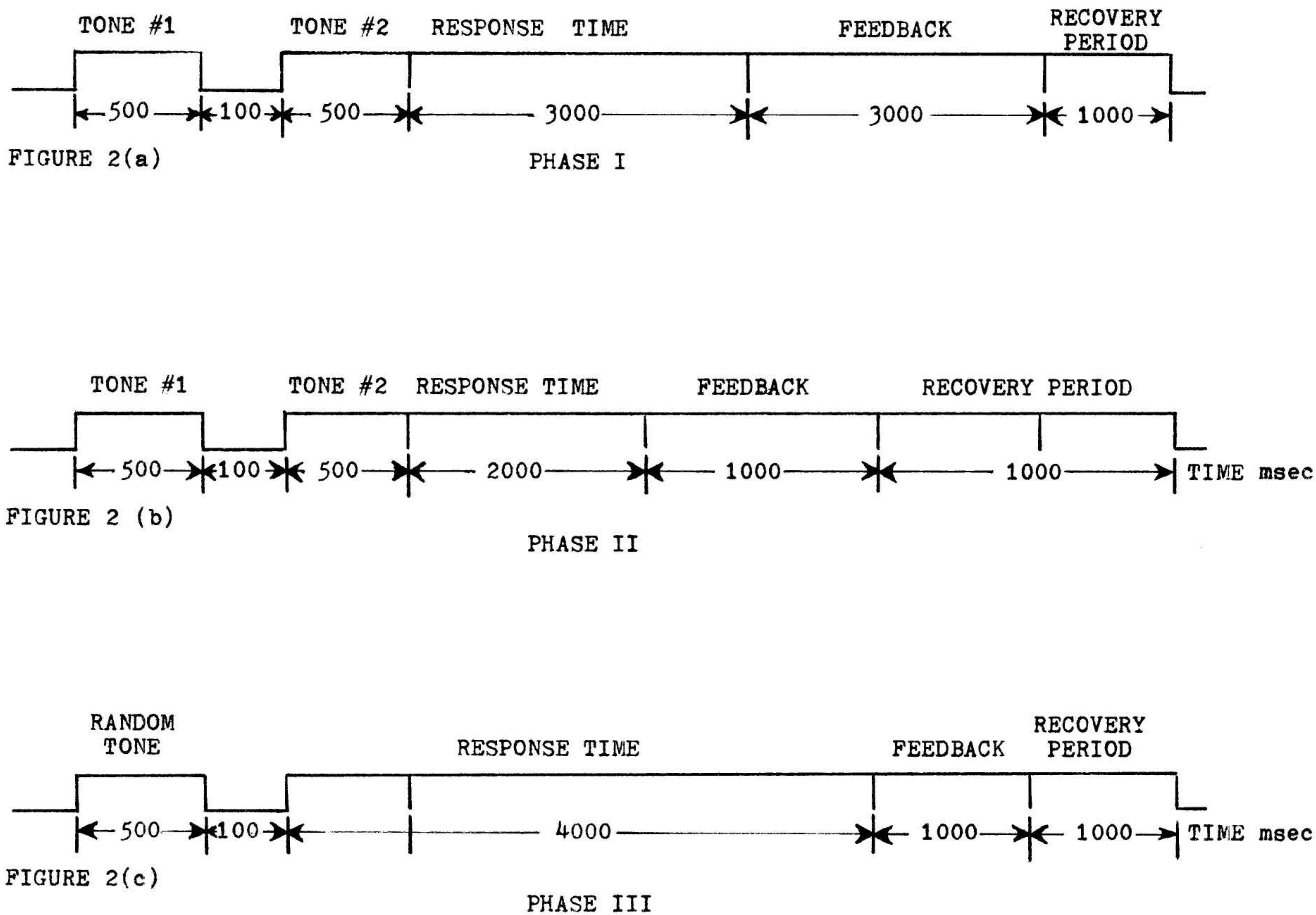
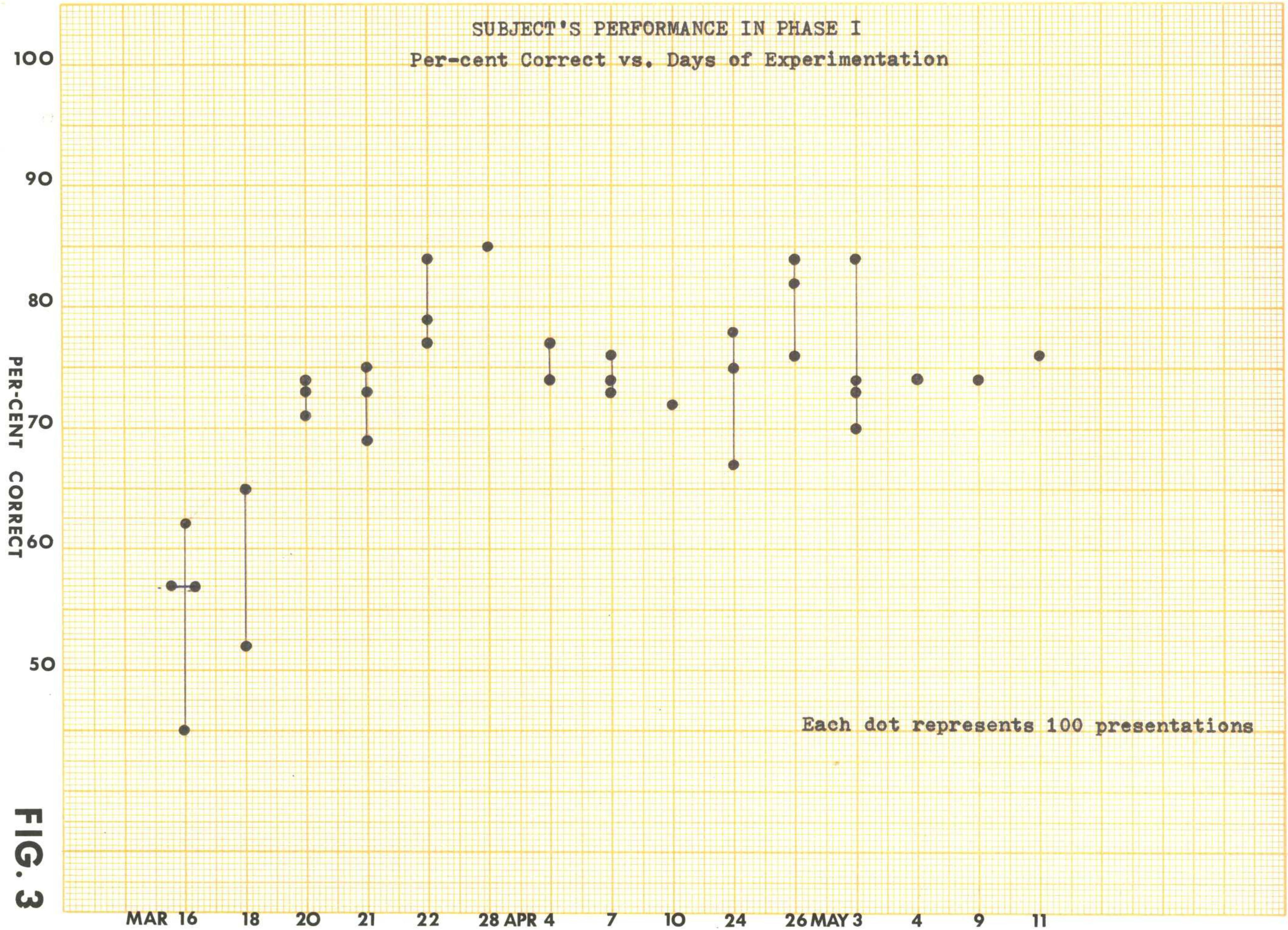


FIG. 2



SUBJECT'S PERFORMANCE IN PHASE I
Per-cent Correct vs. Days of Experimentation
100
90
80
70
60
50
PER-CENT CORRECT
Each dot represents 100 presentations
MAR 16
18
20
21
22
28
APR 4
7
10
24
26
MAY 3
4
9
11

FIG. 3

"BEFORE AND AFTER" TESTS IN PHASE I

The chart below shows the results of some special training which is discussed on pages 10 and 11 in the text.

NEIGHBORING INTERVALS	"BEFORE"	"AFTER"	IMPROVEMENT
12 & 11 semits	62% correct	68% correct	6%
6 & 7 semits	84%	92%	8%
2 & 1 semits	68%	80%	22%
2 & 3 semits	64%	92%	32%
9 & 10 semits	46%	80%	34%

FIG. 4

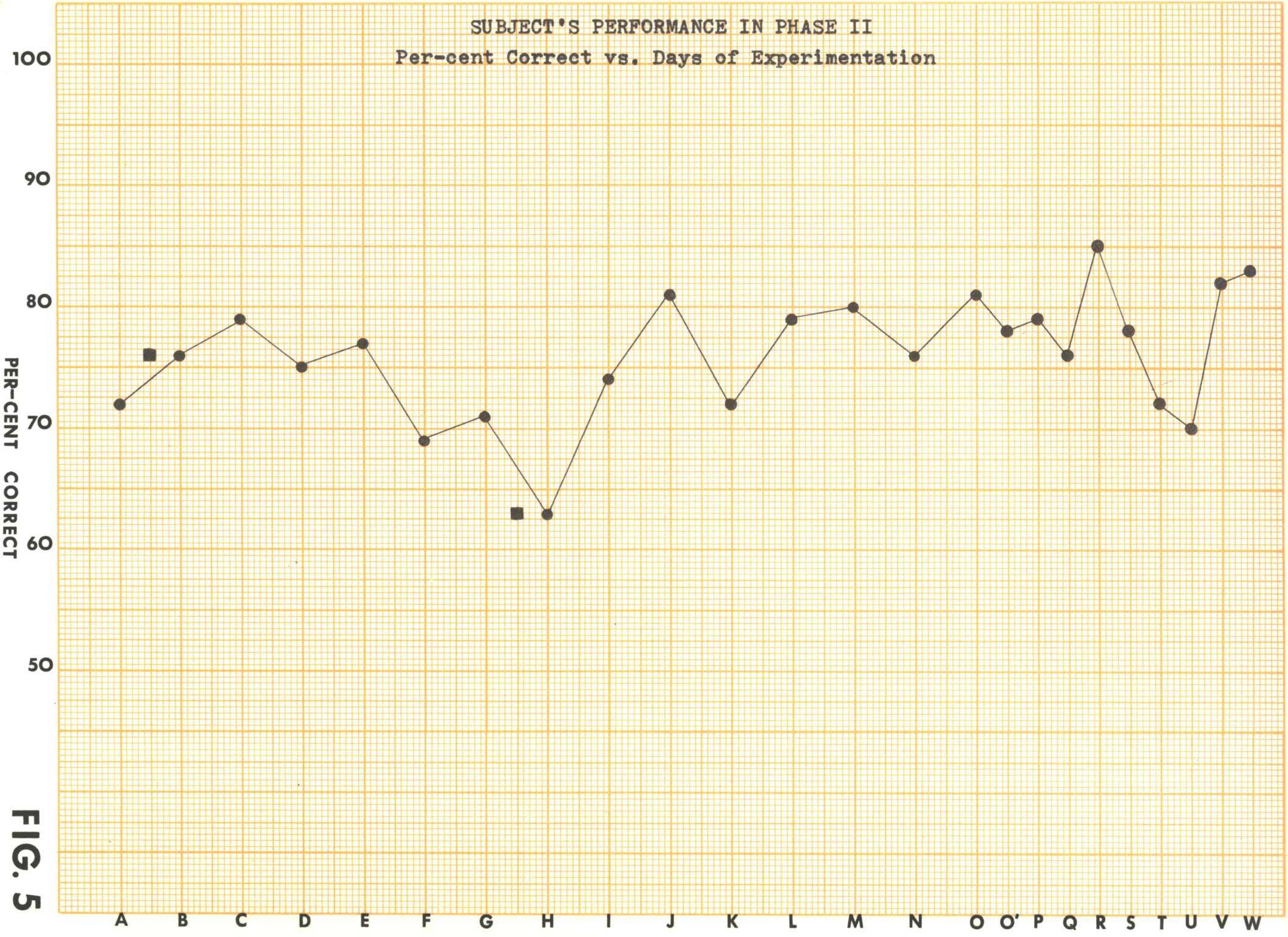

SUBJECT'S PERFORMANCE IN PHASE II
Per-cent Correct vs. Days of Experimentation
PER-CENT CORRECT
100
90
80
70
60
50
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
O'
P
Q
R
S
T
U
V
W

FIG. 5

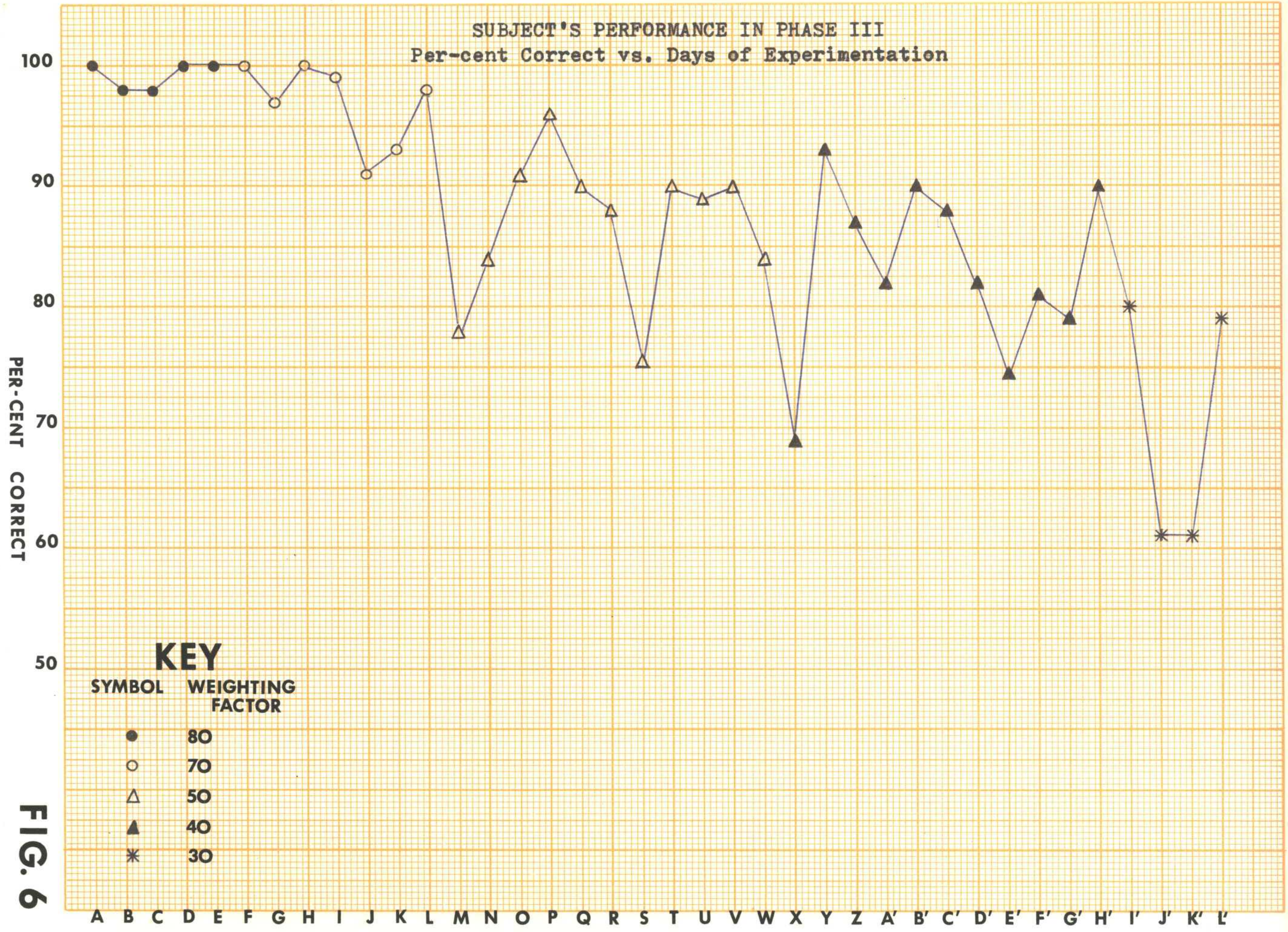

SUBJECT'S PERFORMANCE IN PHASE III
Per-cent Correct vs. Days of Experimentation
PER-CENT CORRECT
100
90
80
70
60
50
KEY
SYMBOL
WEIGHTING FACTOR
80
70
50
40
30
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z A' B' C' D' E' F' G' H' I' J' K' L'

FIG. 6

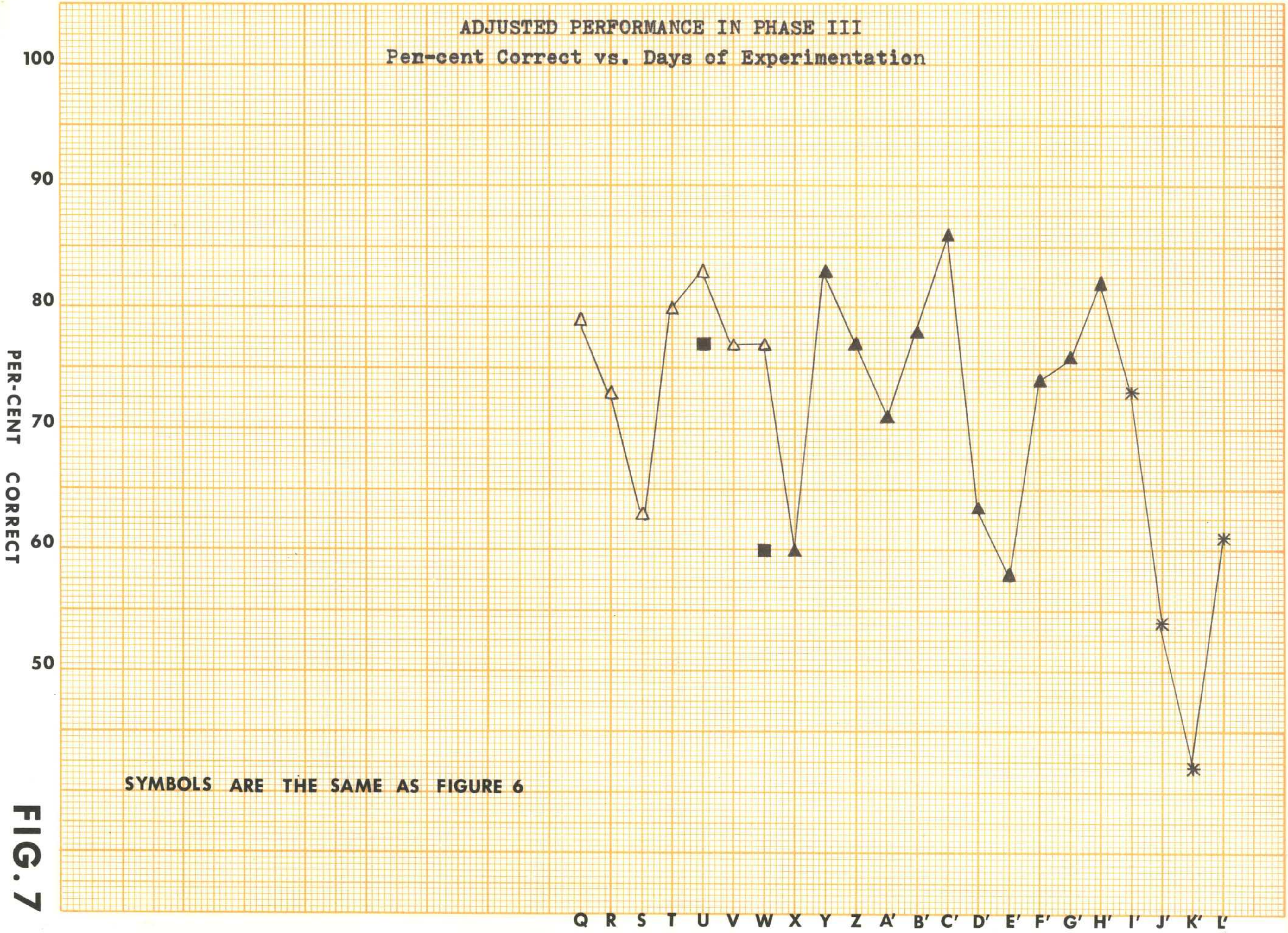

ADJUSTED PERFORMANCE IN PHASE III
Per-cent Correct vs. Days of Experimentation
PER-CENT CORRECT
100
90
80
70
60
50
SYMBOLS ARE THE SAME AS FIGURE 6
Q R S T U V W X Y Z A' B' C' D' E' F' G' H' I' J' K' L'

FIG. 7

RESPONSES

STIMULI (SEMITS)	0	1	2	3	4	5	6	7	8	9	10	11	12
0	154												
1		262	9	3									
2		12	361	10	2	1							
3		7	3	310	8	8	3	3			1		
4			1	31	322	8		3			1		
5				14	7	385		7					
6			1	10		14	198	15	9	12	9	9	
7				3	7	30	2	201	9	3	2		4
8				6	1	9	29	40	118	24	13	11	2
9				1		3	23	17	25	157	19	3	9
10							14	11	15	11	133	23	8
11				1		2	21	5	12	9	72	107	11
12							1	12	4	9	16	3	145

This confusion matrix shows the subject's total performance in PHASE I

FIG. 8

		RESPONSES												
	SEMITS	0	1	2	3	4	5	6	7	8	9	10	11	12
	0	198		1										
	1		365	4	2									
	2		8	297	7	1	3							
	3		9	1	350	12	1	6						
	4			1	51	350	2	1	2					
	5				18	5	321	2	7		1			
STIMULI	6				17	3	10	312	19	13	1	10	2	
	7					5	13	20	273	13	3			1
	8				7	1	12	23	30	189	46	36	2	
	9				2		4	12	8	35	238	41	7	1
	10				3	2	2	9	3	31	51	206	48	9
	11							4	3	12	20	69	221	26
	12						1	1	1		1	7	30	342

FIG. 9

FOOTNOTES

[1] Bachem, A., "Genesis of Absolute Pitch," JASA, 11,146-151, 1940.

[2] Bachem, A., "Absolute Pitch," JASA, 27, 1180-1185, 1955.

[3] Copp, E.F., "Musical Ability," Jour. Heredity, 7,297-305, 1916.

[4] Jeffress, L.A., "Absolute Pitch," JASA, 34, 987, 1962.

[5] Ward, W.D., "Absolute Pitch," Sound, 2, 14-21,33-41, 1963.

[6] Meyer, M., "Is the Memory of Absolute Pitch Capable of Development by Training?" Psychol. Rev., 6,514-516, 1899.

[7] Meyer, M., "On Memorizing Absolute Pitch," JASA, 28, 718-719, 1956.

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