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An investigation of the relationship of two variables to the accuracy of the perception of imbedded visual forms.

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AN INVESTIGATION OF THE RELATIONSHIP OF TWO VARIABLES
TO THE ACCURACY OF THE PERCEPTION OF IMBEDDED VISUAL FORMS

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AN INVESTIGATION OF THE RELATIONSHIP OF TWO VARIABLES
TO THE ACCURACY OF THE PERCEPTION OF IMBEDDED VISUAL FORMS

by

George W. Doten

THESIS SUBMITTED FOR THE DEGREE OF MASTER OF SCIENCE

UNIVERSITY OF MASSACHUSETTS

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INTRODUCTION

Interest was originally aroused in this problem through the desire to answer the practical question as to why students fail certain questions on an examination when they have the information necessary to give the correct answer. This failure seemed to occur because the students had taken an initial wrong step and had misinterpreted the question. This has probably occurred, in one form or another, to the most brilliant scholar, the most steady student, and the most methodical knowledge seeker. Thus the factors of intelligence, previous knowledge, study habits, and others seem to be operating only to a small degree in such instances and some other factor or factors might be sought to explain the failure of the student.¹ One acceptable factor might be the "set" existing at the time of deciding upon the answer.

"Set," as used here, refers to a determining tendency in the sense of the constellation of factors existing just prior to making a response, and is not to be interpreted in the traditional way in terms of postures or other readiesses established by instructions. To clarify this point of view, the following statement by Boring et al (1) exemplifies the present meaning. "It is probable, although experimental evidence in support of it is not yet conclusive, that forgetting depends upon set or determining tendency. That interest or set in a given direction has a selective influence is well known; if the set is in an incorrect direction, recall

¹Morgan (8) has demonstrated experimentally that contradictory factors can be introduced into a problem situation which will be accepted by even the most intelligent individuals attempting to solve the problem. These individuals were required to rank a series of nine buttons according to their effectiveness of ringing a bell. Although five of the buttons were shown not to be effective, the subjects ranked them at the lower end of the scale.

may fail even though with a correct set it may occur." By way of illustration, Boring suggests that if one is seeking to recall a name that he thinks he knows, and decides incorrectly that the name is Scotch, the search will be confined to Scotch names to the neglect of others, and it will seem that the name has been forgotten. An inappropriate group of determining tendencies may thus operate to evoke continually wrong responses, or to prevent the responses from being recognized as correct.

The question may then be asked, "What variables are responsible for a wrong "set" in an examination situation? On questioning some students, many replied that in attempting to work at high speed they misread the question. It would seem then, that if these students had taken more time to understand the question thoroughly, they would have had a better chance to answer the question correctly. Thus the amount of time taken to understand the question would seem to be one variable affecting the adequacy of the set at the time of finally deciding what answer to write.

It was also noted that perhaps the question itself caused the failure. A question of ambiguous nature might, regardless of the amount of time available for its study, arouse so many responses that the individual would not be able to recognize the correct ones. Thus, another variable, ambiguity of the stimulus field, seemed likely to affect the accuracy or effectiveness of the set at the time of decision.

With set conceived as the constellation of determining tendencies existing just prior to response, the problem may equally be considered to be one of perception: How does the student perceive the question at the time of his response? What factors may account for whatever perception is "in force"?

Since the best way to begin to examine the effects of the two variables suggested above is in the experimental laboratory, the practical problem

has been set aside for the present in order that we may examine the psychological processes operant in it at a more basic level. If in the laboratory we find one suggested variable contributing to the adequacy of a problem-solution for which a person has adequate knowledge, a classroom experiment might be designed to answer the practical educational question.

In the laboratory, the problem was investigated as one of perception, the task being the recognition of forms imbedded in a complex field. If the individual knows the name of a geometric form, what effects will decision time (the first variable suggested) and ambiguity of the stimulus field (the second variable suggested) have on the recognition of that form when it is complicated by other lines?

The following statement serves as an orientation to the experiment:

One hundred and eight subjects, comprising three equated groups, learned nonsense syllable names for four geometric forms. Twelve figures, four at each of three defined levels of ambiguity, were exposed briefly. Groups I, II, and III delayed naming the imbedded form for two, four and six seconds, respectively, until the experimenter sounded a buzzer. It was found that accuracy of response decreased as stimulus figure ambiguity increased and that decision time was a determinant of response accuracy only at the most ambiguous level.

STATEMENT OF PROBLEM

This problem is designed to answer the following general question: Other factors being equal, how does the accuracy of recognizing a known form imbedded in a context of lines depend upon the amount of decision time available and the ambiguity of the external stimulating conditions.

This question may be refined and divided into two hypotheses formulated to specify the effects of the two independent variables separately:

1. Other factors being equal, including the ambiguity of the external stimulating conditions, the accuracy with which a known form may be recognized when imbedded in a context of other lines will vary with the amount of time available for the report.

2. Other factors being equal, including the amount of decision time available, the accuracy with which a known form may be recognized when imbedded in a context of other lines will vary with the ambiguity of the external stimulating conditions.

It should be understood that any indication of "set," or the subject's perception at the time of response obtained in this experiment will be inferred from a measure of response correctness and is not in itself directly measured.

APPARATUS

1. Preliminary Experiment

A large laboratory-made memory drum exposed the geometric forms at two second intervals. The drum had a diameter of 12 inches and an exposure window of one and three-quarters inches in height and allowed the exposure of geometric forms three-quarters of an inch high. The exposure window could be varied in its position to permit the exposure of two orders of ten geometric forms placed on the drum. When one order was shown to the subject, the other was concealed.

A modified Dockeray tachistoscope as shown in Figure 1 was employed to expose the ambiguous stimulus field to the subjects. The tachistoscope was 10 1/2 inches high, eight inches wide, and 21 inches long. It was constructed with shaded eye-slots in front and a door in back. On the inside of this door, was a small metal frame which held the stimulus cards. To prevent the subjects from seeing the stimulus cards as they were inserted in the frame, a black cardboard screen was placed inside the tachistoscope just in front of the door. A piece of heavy flexible wire fastened to the inside of the door just above the card frame raised the screen as the door closed. Illumination was provided by a three volt flashlight bulb inserted in an opening above eye level and slightly ahead of the eye-slots (See x in Figure 1). The bulb was operated by three one and one-half volt batteries connected in series. A flashlight reflector and ground glass lens concentrated an even light on the stimulus cards.

A telechron motor (one revolution per second) operating on house current (110 volts) provided the means of controlling the length of illumination time (See y in Figure 1). A copper disc was soldered to the end of the motor's shaft and a flexible contact point was mounted so as to come in

contact with the disc's edge. Since only .33 seconds exposure was to be allowed each subject, the diameter of two-thirds (240 degrees) of the disc was decreased, so that only one-third of the disc's circumference could actually touch the flexible contact point. In this manner the desired exposure time was obtained, since during one second revolution of the motor only one-third of the disc was in contact with the flexible point. When the subject was ready to be shown the stimulus cards, the telechron motor was started, and run throughout the experiment. To enable the experimenter to have final control over the light, a telegraph key was connected into this circuit. Thus by depressing the key, the experimenter could allow the automatic timer to close the circuit for .33 seconds.



Figure 1

Tachistoscope and accessory apparatus for exposing materials

A buzzer operated by battery and controlled by another telegraph key, was used to signal the subject when to respond.

2. Main Experiment

A Lipmann-type memory drum was used in the main experiment. However, the regular window was replaced with a larger one so that forms one-half inch in height could be exposed. The drum also exposed the forms at two second intervals.

The tachistoscope described previously and illustrated in Figure 1 was also used in the main experiment to expose stimulus cards.

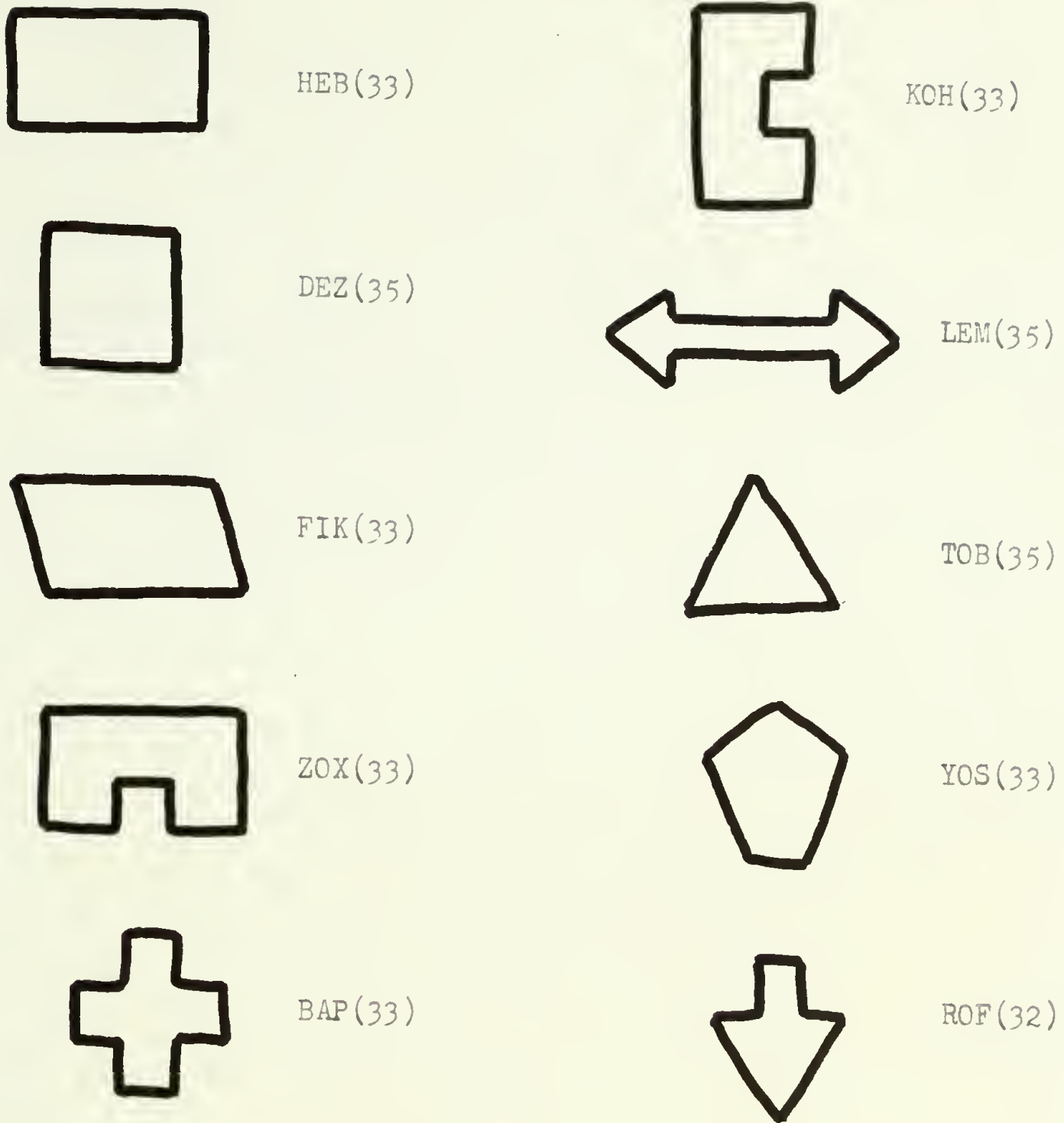


Figure 2

The ten geometric forms and nonsense syllables (association values in parentheses) used as learning materials in preliminary experiment.

MATERIALS

1. Preliminary Experiment

Ten geometric forms were drawn by the experimenter. These forms (illustrated in Figure 2) were selected on the basis of their symmetry. Ten nonsense syllables were selected from Hull's list (6) on the basis of homogeneous association values; these syllables are also given in Figure 2, with their association values in parentheses.

The nonsense syllables were paired with the geometric forms and two lists of form-syllable pairs were constructed so that two different orders could be presented on the memory drum. The different orders prevented the subjects from learning the nonsense syllable associated with the form according to its position in the list. In each list the geometric form was first exposed and followed by the geometric form paired with its nonsense syllable after a two second interval.

Forty Gottschaldt-type figures² of varying degrees of apparent complexity were drawn in black India ink on three by five inch white file cards. This process consisted of drawing a form and then complicating it with other lines. The lines were approximately one eighth inch thick and of constant luminosity. Each figure contained only one form, care being taken to exclude any of the others in the lines used to complicate the figure. The form's location was varied from figure to figure. Only four forms out of the original ten were imbedded in the figures. These four forms were the forms to be used in the main experiment and were TOR, triangle; REE, rectangle; FIK, parallelogram; and DEZ, square. The subjects were

²The stimulus figures used in this study were named "Gottschaldt-type" figures since Gottschaldt (4) was the first to construct them.

required to learn the ten forms originally to enhance their confusion in searching for the correct forms in the figures just described. An illustration of the Gottschaldt-type figures is presented in Figure 3.

2. Main Experiment

The materials in the main experiment were the four forms and the nonsense syllables paired with them as given on page 11. Again two lists were prepared and exposed on the memory drum with the geometric forms appearing first and the geometric forms paired with their respective nonsense syllables following at two second intervals.

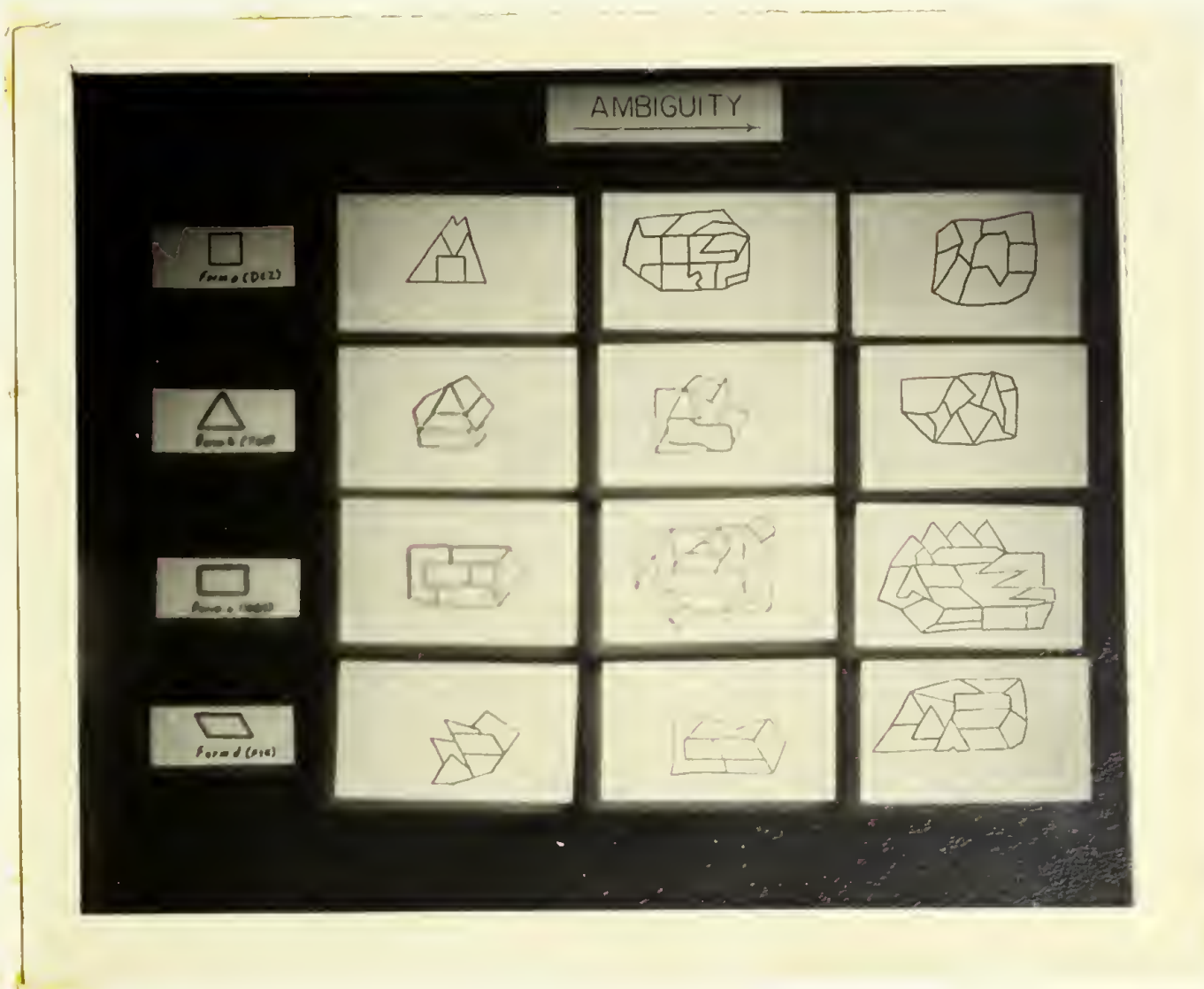


Figure 3

The twelve selected Gottschaldt-type figures
used in the Main Experiment

Twelve Gottschaldt-type figures (shown in Figure 3) were selected from the original forty to be used as the stimulus cards in the main experiment. These figures were chosen as an outcome of the preliminary experiment which is described in the following section.

PROCEDURE

1. Preliminary Experiment



The preliminary experiment was conducted to give an operational distinction between the degrees of ambiguity of the stimulus cards and to ensure approximate equality of differences in levels of ambiguity. "Ambiguity," operationally defined, will be the inverse amount of agreement among the subjects as to which form is imbedded in the Gottschaldt-type figures. For the levels of ambiguity used in the main experiment, the criteria for the amounts of agreement were set at 85-100% for the first or lowest level of ambiguity, 42.5-57.5% for the second or middle level of ambiguity, and 0-15% for the third or highest level of ambiguity.

To obtain the desired levels, the preliminary experiment followed this procedure: 30 subjects were chosen at random from the same population from which the subjects in the main experiment were to come. Each of the subjects was required to go through two experimental phases.

In the first phase the subjects learned to associate ten geometric forms with ten nonsense syllables to a criterion of two perfect trials. Two overlearning trials were given to ensure that this learning would not be forgotten. The instructions given to the subjects were as follows:

"In this part of the experiment, you are to look into this window of the memory drum and learn the geometric forms presented by associating them with the proper nonsense syllables. As the drum goes around, you will first see a geometric form which will be followed by the same geometric form paired with a nonsense syllable. When this sequence appears again, you are to give the nonsense syllable when you see the geometric form without the syllable. Do not hesitate to guess. Are there any questions?"

In the second phase of the preliminary experiment after he had learned the paired associates problem just described, the subjects were seated in front of the tachistoscope and received the following instructions:

"In this part of the experiment, you are to look into this window of the tachistoscope and report which of the forms you learned in the first part is contained within the figure you will see. The form will always be in an upright position; that is TOS will look like this,  not this . Your response will be made in terms of the nonsense syllable associated with that particular form and must be given immediately. Remember, when the light goes off, name the form immediately using the nonsense syllable which you have learned to associate with it. You will be shown two practice cards to show you where to look and how long the light will be on. Are there any questions?"

First the experimenter exposed the two practice cards to the subjects. The first practice card said "Look Here" and the second said "Psychology is the Master Science."

The experimenter then exposed the 40 Gottschaldt-type figures in a random order, which was determined before hand. For every five subjects the order of presentation of the figures was reversed to counterbalance any serial position effects that might affect the accuracy with which the imbedded forms could be recognized.

Only correct responses were tallied on the record sheet, and the total number of correct responses for each figure were added for later conversion into percentages.

The data resulting from the preliminary experiment are given in a later section (page 23). On the basis of these data the 12 figures shown in Figure 3 (page 12) were selected for use in the main experiment.

2. Main Experiment

According to the hypotheses set forth in "Statement of Problem" this experiment is designed to answer two questions. First, Is there a relationship between the amount of decision time available and the accuracy of response when judging whether or not a previously learned form is contained within an ambiguous visual field? And secondly, Is there a relationship between the ambiguity of the field and the accuracy of response when judging whether or not a known form is imbedded in that field.

To answer these questions the experiment was set up in the following way: three groups of 36 subjects each were made up and matched with respect to sex, means of age, number of trials to learn the geometric form associated with the nonsense syllables, and intelligence test scores.³ Each subject of each group was required to make 12 judgments as to whether or not a previously learned geometric form was imbedded in an ambiguous Gottschaldt-type figure as shown in Figure 3.

The groups were labeled I, II, and III according to the amount of decision time allowed the subjects within the groups. Subjects in Group I, the two second group, were required to delay two seconds before giving their answer. Subjects in Group II, the four second group, were required to delay four seconds before giving their answer, and subjects in Group III, the six second group, were required to delay six seconds before giving their answer. In each case, the experimenter sounded a buzzer to signal the subject to respond.

³Since intelligence test scores were not available for all subjects used in this experiment, subjects without known test scores were assigned to the groups at random. It was assumed that this procedure would not introduce any systematic bias in the groups. A simple sampling experiment, in which subjects with known test scores were assigned at random to three groups of 10 subjects each, supported this assumption, since no significant differences were found between the means of the groups.

Diagrammatically the experimental design takes the form of Figure 4.

	Group I (2 sec.)	Group II (4 sec.)	Group III (5 sec.)
Ambiguity Level 1	Form a	Form a	Form a
	Form b	Form b	Form b
	Form c	Form c	Form c
	Form d	Form d	Form d
Ambiguity Level 2	Form a	Form a	Form a
	Form b	Form b	Form b
	Form c	Form c	Form c
	Form d	Form d	Form d
Ambiguity Level 3	Form a	Form a	Form a
	Form b	Form b	Form b
	Form c	Form c	Form c
	Form d	Form d	Form d

Figure 4

Diagram of Experimental Design

Figure 4 indicates that all subjects, regardless of their assignment to any particular group, will be presented with the same stimulus cards of Gottschaldt-type figures.

The stimulus cards, designated as "events" were numbered 1-12 following the order of Table 1.

The small letters, a, b, c, and d, symbolize the square (DEZ), the triangle (TOB), the rectangle (NEP) and the parallelogram (FIK). Table 1 shows, for example, that event No. 1 is made up of form 2 imbedded in a context at the first level of ambiguity while event No. 6 is made up of form b imbedded in a context at the third level of ambiguity.

Table 1 Designation of Events

Event	Form Imbedded in Figure	Ambiguity Level
1.	a	1
2.	b	2
3.	c	3
4.	d	2
5.	c	1
6.	b	3
7.	a	2
8.	d	3
9.	b	1
10.	a	3
11.	c	2
12.	d	1

To control serial position effects within the experimental procedure a randomization table was prepared, Table 2, so that all events would be presented to the subjects in all possible serial positions.

Thus, for example, subjects numbered 5, 17, and 29 in any of the three time delay groups would be exposed to the following sequence of 12 events: form c at ambiguity level 1; form b at ambiguity level 3; form a at ambiguity level 2; form d at ambiguity level 3; form b at ambiguity level 1; form a at ambiguity level 3; form c at ambiguity level 2; form d at ambiguity level 1; form a at ambiguity level 1; form b at ambiguity level 2; form c at ambiguity level 3, and form d at ambiguity level 2.

Again the experimental procedure was divided into two phases. In the first phase, the subjects were required to learn the four main forms paired with their respective nonsense syllables to a criterion of three perfect trials. To ensure permanent learning throughout the experiment, 100% overlearning was then given to each subject.

Table 2 Sequence of Events for each subject in any group

	1	2	3	4	5	6	7	8	9	10	11	12
Subject Numbers	13	14	15	16	17	18	19	20	21	22	23	24
	25	26	27	28	29	30	31	32	33	34	35	36
Events	1	2	3	4	5	6	7	8	9	10	11	12
	2	3	4	5	6	7	8	9	10	11	12	1
	3	4	5	6	7	8	9	10	11	12	1	2
	4	5	6	7	8	9	10	11	12	1	2	3
	5	6	7	8	9	10	11	12	1	2	3	4
	6	7	8	9	10	11	12	1	2	3	4	5
	7	8	9	10	11	12	1	2	3	4	5	6
	8	9	10	11	12	1	2	3	4	5	6	7
	9	10	11	12	1	2	3	4	5	6	7	8
	10	11	12	1	2	3	4	5	6	7	8	9
	11	12	1	2	3	4	5	6	7	8	9	10
	12	1	2	3	4	5	6	7	8	9	10	11



After the subjects were seated in front of the memory drum, they received the following instructions:

"In this part of the experiment you are to look into the window of the memory drum and learn the geometric forms presented by associating them with the proper nonsense syllables. As the drum goes around, you will first see the geometric form which will be followed by the same geometric form and a nonsense syllable. When you see the geometric form without the nonsense syllable, you are to respond with the nonsense syllable before that

form and the nonsense syllable appear. Do not hesitate to guess. When you reach the point where you are able to anticipate the nonsense syllables correctly three times in succession, you have learned this task. To ensure that this learning is permanent throughout the experiment, you will then be given as many additional trials as it took to learn them originally. Are there any questions?"

In the second phase of the experiment, which followed the first immediately, the subjects were required to make 12 judgments as to which of the forms learned in the first phase was imbedded in the ambiguous Gottschaldt-type figure.

The subjects were seated in front of the tachistoscope and received the following instructions:

"In this part of the experiment, you are to look into this window of the tachistoscope and report which of the forms you learned in the first part of the experiment is contained in the figure that you will see. The form will always be in an upright position; that is TOB will look like this  not this  . Your response will be made in terms of the nonsense syllable associated with that particular form. However, you will ^{not} respond until the experimenter sounds a buzzer. Remember you are not to give the name of the form until the buzzer is sounded. When it is sounded, name it immediately using the nonsense syllable which you have learned to associate with it. The first two cards you will see are for practice to acquaint you with the length of exposure and to show you where to look. Are there any questions?"

The same two practice cards as used in the preliminary experiment were first shown to the subjects.

After each card was exposed to the subject for .33 seconds, the experimenter sounded the buzzer at the appropriate time interval (two, four, or six seconds, depending upon the group, I, II, or III, to which the subject was assigned) to signal the subject to respond. If the subjects identified the form imbedded in the figure correctly, they were scored as correct; otherwise they were simply scored incorrect for that response.

To ensure adequate testing of the hypotheses, variables other than those specified in the hypotheses and possibly related to the performance of the required task, had to be controlled. These variables and the manner of their control are summarized in Table 3.

After the second phase of the experiment was completed, the experimenter asked the subjects the following questions:

1. "Would you describe your thought processes between the time that you saw the form and you gave your answer?"
2. "Did you use any different type of process in picking the correct form out of the more difficult figures as compared to the simpler ones?"
3. "Do you think that the time delay aided or interfered in selecting the correct form in the more difficult figures?"
4. "Would longer time delays help in reaching the solution?"

The information gained from this questionnaire was used to supplement the knowledge of the two variables gained from the experimental procedure.

Table 3 List of extraneous variables and how they were controlled

VARIABLES	CONTROL
1. Amount of time available for the decision.	2, 4, and 6 second time delays were used. If the subject did not respond within a half second of these times, the response was scored incorrect.
2. Length of tachistoscope exposure.	.33 seconds was used for exposure time and was determined by a pre-test using eight subjects.
3. Motivation of subjects	Each subject received one point to be added to his final grade in whatever psychology course he was enrolled.
4. Amount of original learning of task to be performed	Each subject was required to learn the geometric forms paired with nonsense syllables to criterion of three perfect trials which was followed by 100% overlearning.
5. Serial position effects within experimental procedure.	Controlled by the randomization of the sequence of events. (See Table 2).
6. Effects of guessing on performance of task.	When interpreting results in terms of percent correct responses comparisons were made with 25%.
7. Amount of learning throughout experiment.	Only one trial was given to each subject at each stimulus figure

RESULTS

1. Preliminary Experiment

Since the purpose of the preliminary experiment was to secure an operationally meaningful distinction between the degrees of the ambiguity and to equate differences based on the criteria of amounts of agreement among the subjects, analysis of results was confined merely to finding three Gottschaldt-type figures for each of the four main forms which met the criteria. The 12 figures chosen are shown in Figure 3 on page 12. The following table indicates the percent of subjects who agreed upon the correct imbedded form. The table is arranged in the same order as Figure 3.

Table 4

Percents of Agreement Among Thirty Subjects
As to the Imbedded Form in the 12 Gottschaldt-
type Figures (N = 30)

Form	Ambiguity Levels		
	1	2	3
a (DEZ)	93%	53%	13%
b (TOB)	93%	50%	13%
c (HEB)	83% ⁴	57%	10%
d (FIK)	83% ⁴	53%	3%

2. Main Experiment

a. The relationship between accuracy of response and decision time.

The quantitative results of this experiment are presented in Tables 5 and 6.

⁴Although the difference between 83% and 85% is probably not statistically significant, a line was withdrawn from each of the figures showing 83% agreement to approximate our original criterion of 85-100% agreement for the easiest or first level of ambiguity.

Table 5

The Mean Scores and Standard Deviations of Each Group at Each Level of Ambiguity (N = 36)

Ambiguity Level	Groups					
	I		II		III	
	M	SD	M	SD	M	SD
1	3.22	1.03	3.03	.95	3.33	.76
2	2.28	1.32	2.39	1.03	2.53	1.00
3	.83	.93	.92	.78	1.25	1.00

Table 6

The Percent of Correct Responses and Standard Error of Each Group at Each Level of Ambiguity (N = 144)⁵

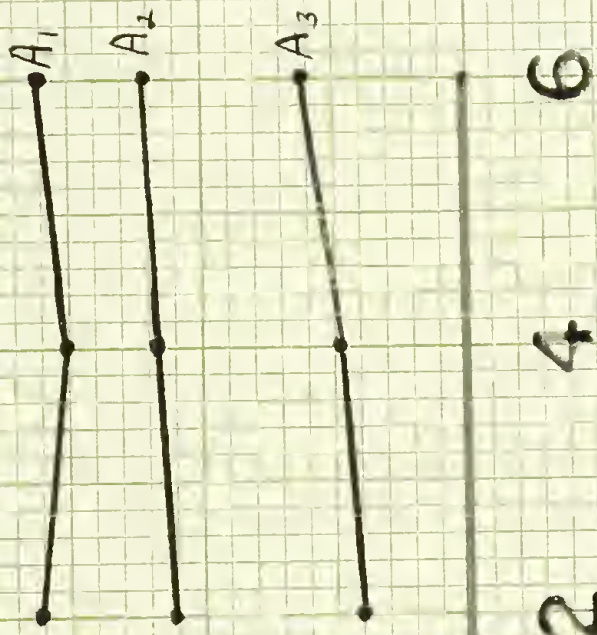
Ambiguity Level	Groups					
	I		II		III	
	%	SE%	%	SE%	%	SE%
1	80.5	3.3	75.7	3.60	83.3	3.11
2	57.0	4.01	59.0	4.09	63.1	4.12
3	21.8	3.3	23.0	3.50	31.2	3.97

Figures 5 and 6 contain the data of Tables 5 and 6 arranged to indicate the relationship of the amount of decision time to the accuracy of response. In Figure 5 the ordinate is expressed in units of mean correct responses on a scale from 0-4 since the maximum score at any one

⁵ Since each subject was required to give four responses at each level of ambiguity, the "N" used in computing the percentage of correct responses was 144.

Mean Correct Responses (N-36)

4
3
2
1

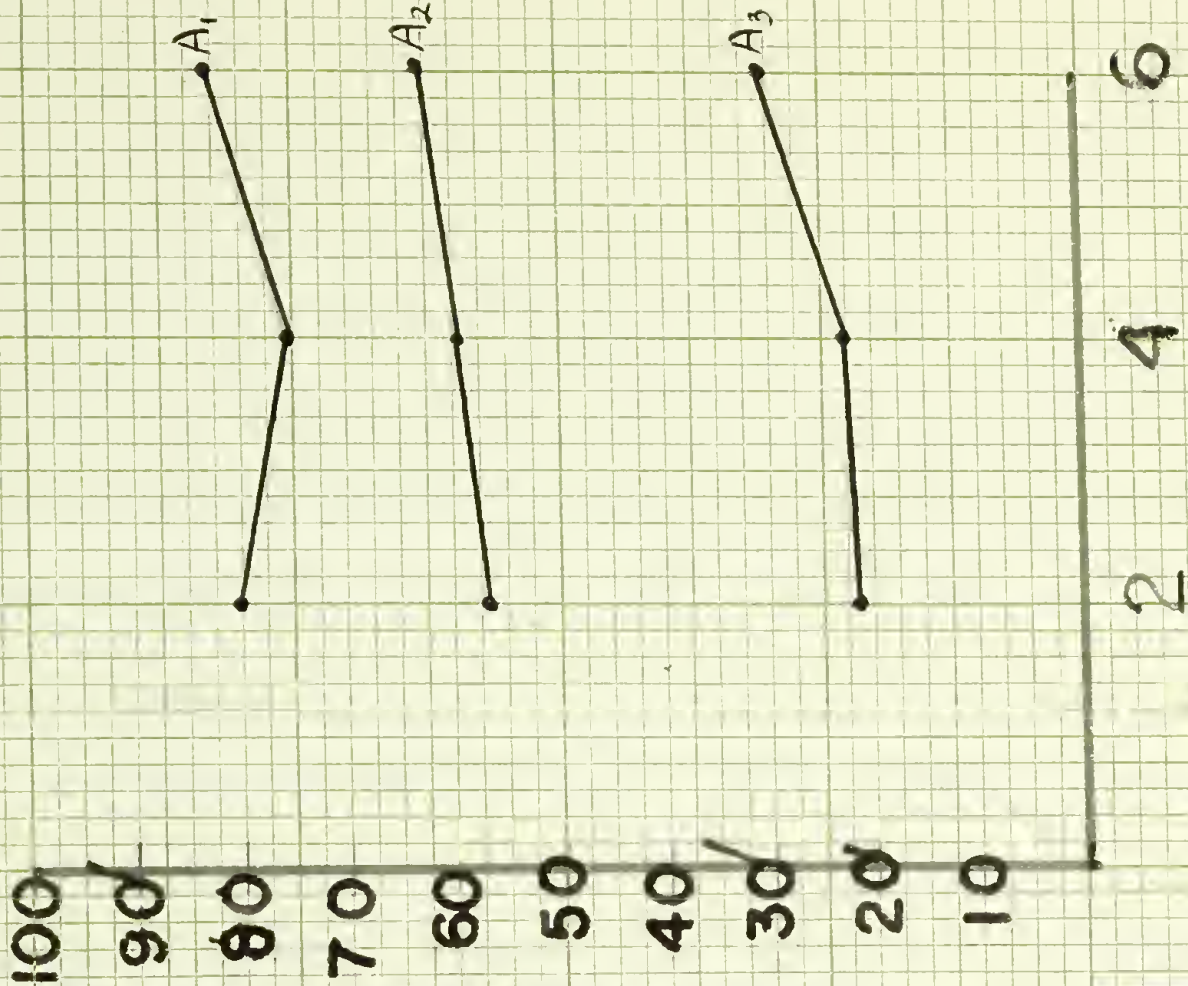


Decision Time (in seconds)

Figure 5

Relationship between mean correct responses and decision time. The curves labeled A₁, A₂, and A₃ represent the performance of all groups at each level of ambiguity.

Percent Correct Responses (N-176)



Decision Time (in seconds)

Figure 6

Relationship between percent correct responses and decision time. The curves labeled A₁, A₂, and A₃ represent the performance of all groups at each level of ambiguity.

level of ambiguity that any subject could obtain was four. (That is, it was possible for the subject to identify correctly anywhere from zero to all four basic forms at any level of ambiguity.) On the abscissa, the decision times, two, four, and six seconds, (for Groups I, II, and III) are scaled.

From the shape of these curves it is evident that the trend is in favor of longer time delays; that is, more correct responses were made by the six second group, Group III, than any other group. The difference of .42 between the mean scores of Group I and Group III at the third level of ambiguity, .83 and 1.25 respectively, was significant at the .05 level using Festinger's technique ($F = 1.51$).⁶

Figure 6 also illustrates the relationship between decision time and accuracy of response. However, the units on the ordinate express the percentage of correct responses for each group at the three levels of ambiguity as shown in Table 6. The number of judgments, of which each point on the curves represents the percent correct, is 144 (4 judgments by each of 36 subjects). Again the shapes of the curves indicate that the trend is in favor of longer decision times. However, we find no differences that are statistically significant at any level of ambiguity. This is not surprising since the only difference found to be significant between means of correct responses is that between Groups I and III using Festinger's technique. Moreover, none of the percents of correct responses was significantly different from chance. This would seem to indicate that with highly

⁶The technique as put forth by Festinger (3) involves finding the significant differences between the means of skewed populations. The means are compared directly, the larger being the numerator, the smaller the denominator with the degrees of freedom equal to $2np$ where p is equal to the mean squared divided by the variance and n is equal to 36. Festinger's technique yields a statistic similar to Fisher's 't', but unlike the 't', it may be used to interpret differences in means of distributions that are skewed.

Percent Correct Responses (N=144)

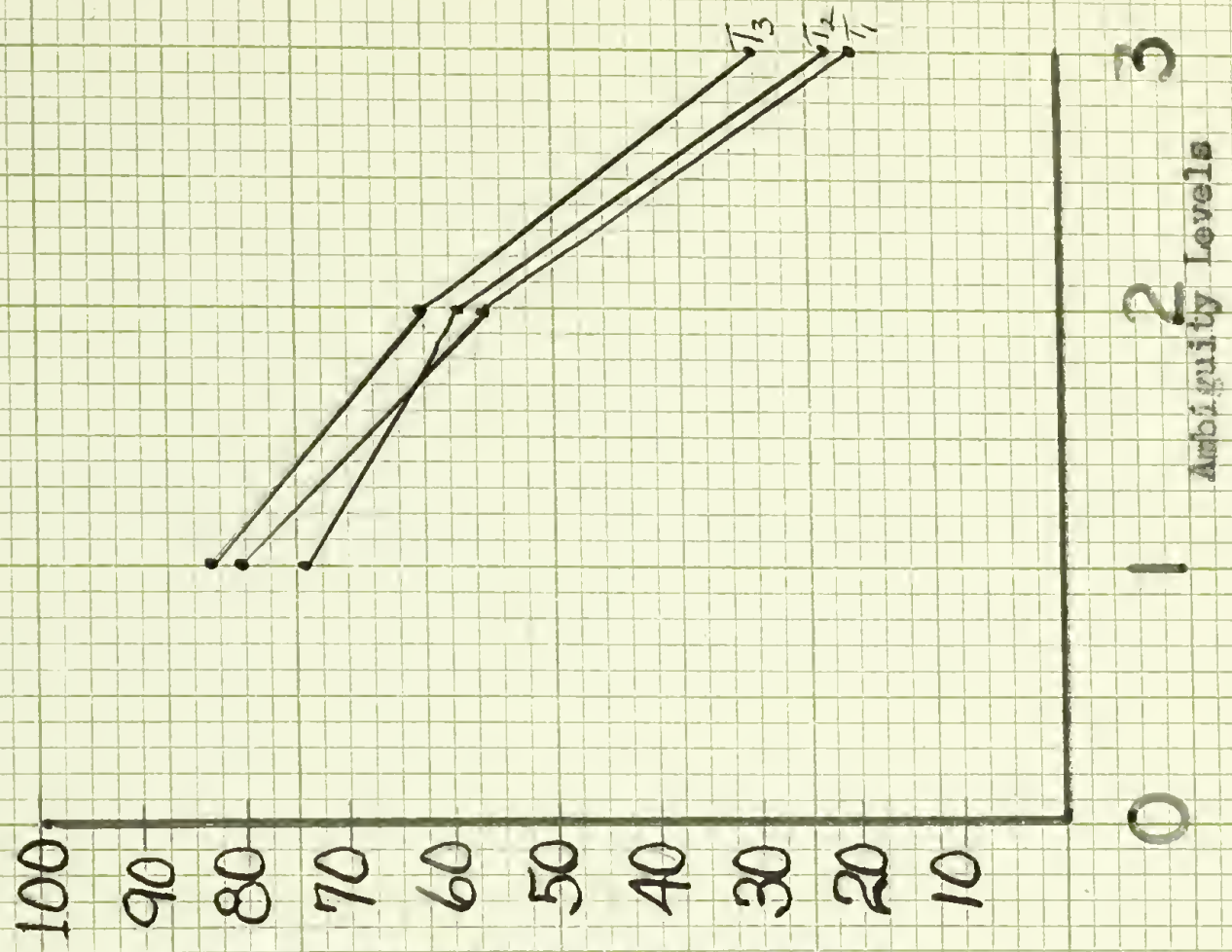


Figure 8

The relationship between percent correct responses and ambiguity of the stimulus field. The curves labeled T1, T2, and T3 represents the performance of each group at each ambiguity level.

Mean Correct Responses (N=36)

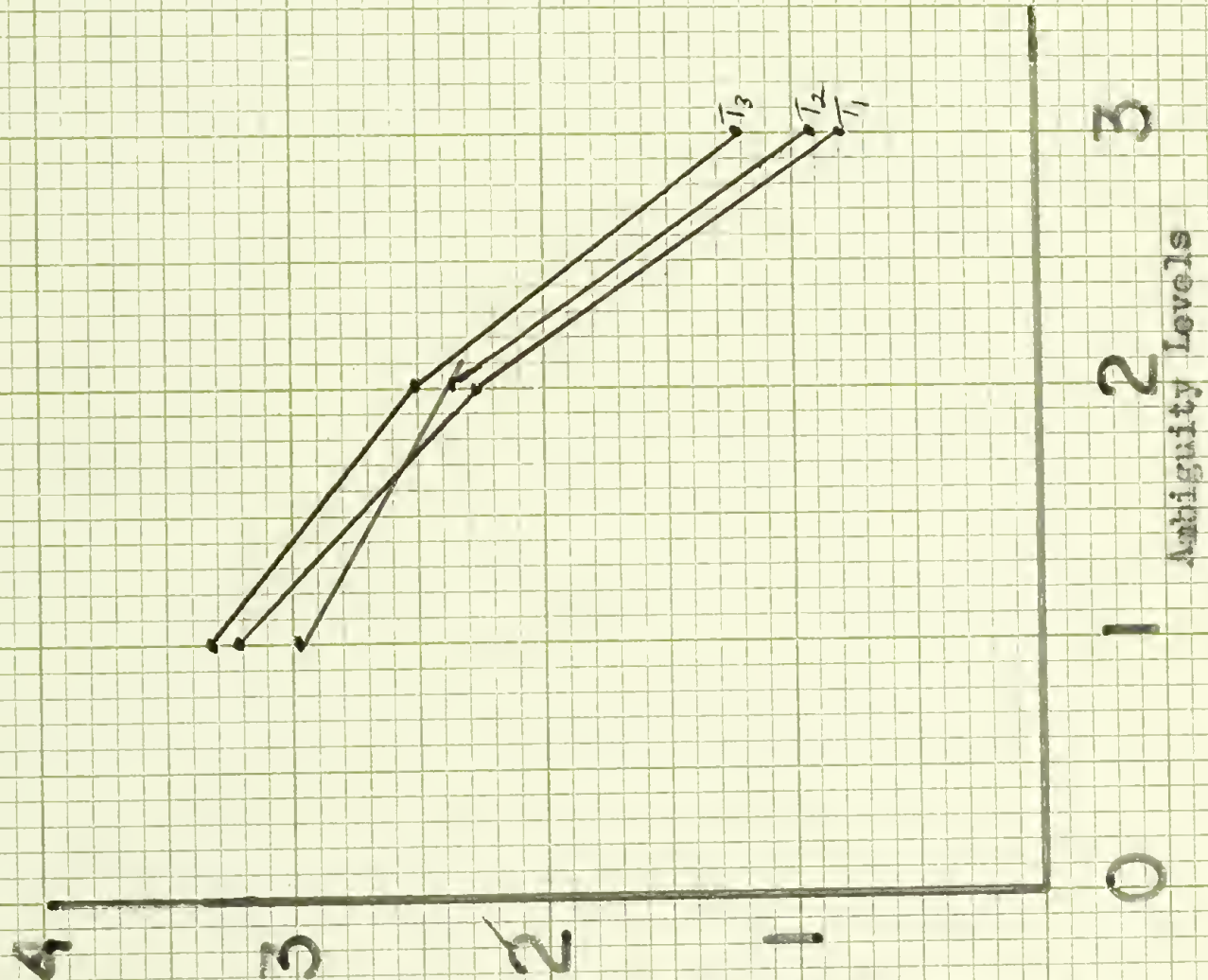


Figure 7

The relationship between mean correct responses and ambiguity of the stimulus field. The curves labeled T1, T2, and T3 represents the performance of each group at each ambiguity level.

ambiguous "information input" the subjects might as well have guessed blindly as to the presence or absence of the form.

- b. The relationship of accuracy of response to the ambiguity of the external stimulating conditions.

In Figures 7 and 8 the data of Tables 5 and 6 are arranged to indicate the relationship of the complexity or ambiguity of the visual field to the accuracy of response. In Figure 7 the ordinate is expressed in mean correct responses for each group at each level of ambiguity on a scale from zero to four. Ambiguity levels 1, 2, and 3 are plotted on the abscissa.

The curves in Figure 7 indicate that the trend in response correctness is in favor of the least ambiguous figures. All differences between the means on each of the curves T_1 , T_2 , and T_3 are significant beyond the .01 level using the 't' test for the differences between means of related measures.⁷ Thus a sharp decrease in the accuracy of recognition, as expressed in mean number of correct responses, of a known form imbedded in a context of other lines is manifested with increasing stimulus field ambiguity.

Figure 8 indicates the same relationship as Figure 7 although the ordinate is expressed in units of percent correct responses. The trend of these curves again reflects the decrease in accuracy of response with an increase in complexity. All differences between differences in percentages

⁷Lindquist (7) gives the formula for this test as:

$$\frac{M_1 - M_2}{\sqrt{\frac{\sum d^2}{n(n-1)}}}$$

This formula was used since the measurement of ambiguity effects involves the comparison of each individual's score at one level of ambiguity to his score at another level of ambiguity, and hence takes into account intra-individual consistency (or correlation) between performances at different ambiguity levels. The effect is to reduce the magnitude of a mean difference required for significance by reducing the standard error of a given mean difference.

are significant beyond the .01 level (all ratios of differences in percent to their standard errors exceeded 2.58).

c. Questionnaire results

The brief questionnaire given at the end of this experiment was used to gain further knowledge of the two variables of decision time and ambiguity. More specifically, we were interested in finding out what use the subjects made of the time delay and how this delay affected the ambiguity of the stimulus field. We had anticipated that they would take this time for implicit trial and error or revisualizing the image. The results of the questionnaire are given in Table 7. The design of the experiment permits interpretation of these results only as they relate to the variable of time delay.

None of the percentages given in Table 7 are significantly different from each other.

Table 7 Questionnaire Responses

Row No.		Groups		
		I	II	III
1	Question 1: Would you describe your thought processes between the time you saw the figure and gave your answer?			
2	Thinking of Syllables	53%	53%	31%
3	Retracing Image	33%	44%	50%
4	Waiting for Buzzer	11%	6%	19%
5	Question 2: Did you use any different type of process in picking out the more difficult figures as compared to the simpler ones?			
6	Retracing Image	19%	11%	17%
7	Concentrated more on Image When Shown	19%	33%	25%
8	No Difference	58%	56%	58%
9	Question 3: Do you think that the time delay aided or interfered in selecting the correct form in the more difficult figures?			
10	Aided	56%	47%	64%
11	Interfered	17%	17%	11%
12	No difference	27%	36%	27%
13	Question 4: Would longer time delays help in reaching the solution?			
14	Yes	8%	3%	8%
15	No	95%	97%	92%

Interpretation of Results

It may be recalled that the first hypothesis proposed for experimental testing was: Other factors being equal, including the ambiguity of the external stimulating conditions, the accuracy with which a known form may be recognized when imbedded in a context of other lines will vary with the amount of time available for the report. The experimental situation required subjects in three equated groups to identify a previously learned form imbedded in a Gottschaldt-type figure which was exposed for .35 seconds.

The results show that Group III named the correct form more often than any other group (See Tables 5 and 6). However, the differences between all the groups at the first two levels of ambiguity, lowest and intermediate, were not significant statistically. It is assumed, then, that decision time is not a determinant of response accuracy when the stimulus field is relatively unambiguous. However, with the application of Festinger's technique, a significant difference at the .05 level between the mean correct responses (Table 5) of Group I and Group III at the highest level of ambiguity was found. Thus a tentative conclusion might be stated in this manner: The effectiveness of the time delay seems to depend upon the ambiguity of the stimulus context. In other words, when the stimulus field is relatively uncomplicated little time is needed to identify a portion of that field. The opposite was true in extremely complicated stimulus fields. It may be further hypothesized that ambiguity as measured in this experiment reflects the number of alternative responses aroused by the stimulus context. In such a process of tentatively making alternative responses (in some terminologies called "hypotheses"--see below), the individual needs, and can to some extent use effectively, extra time to reach

eventually the answer he believes to be correct.

However, this tentative conclusion must be qualified to take into account the results of Table 6. When the data were converted into percents of correct responses, no significant differences were found between the groups at any level of ambiguity. Moreover, none of the percentages of correct responses of the groups at the highest level of ambiguity were significantly different from chance, indicating that the subject might as well have guessed as to the correct imbedded form. Hence a final conclusion, as to the effects of decision time on accuracy of response, might read in this manner: Little time is needed for a decision for relatively unambiguous stimulus fields, but for very ambiguous fields extra time aids the individual to approach and exceed chance expectations. (Compare this conclusion with the results and conclusions of the zero-delay group described on page 41 .)

The second hypothesis was: Other factors being equal, including the amount of decision time available, the accuracy with which a known form may be recognized when imbedded in the context of other lines will vary with the ambiguity of the external stimulating conditions. This hypothesis was tested by comparing scores (expressed as means or percentages of correct responses) of 35 subjects at one level of ambiguity to their scores at other levels of ambiguity. In these comparisons, decision time is held constant, since the comparisons take place within each group instead of among the groups. The mean scores, as given in Table 5, decrease sharply with each increase in ambiguity. The mean differences were all statistically significant and thus it is concluded that the accuracy in judging whether a known form is imbedded in a complex stimulus field, is, under the conditions of this experiment, dependent on the degree of complexity

of the field. That is, the more complex the field, the lower the accuracy. Or the more responses that are evoked, or evokable, the less chance there is to arrive at a correct one.

The percentage of correct responses, tallied in Table 6, also points to this same conclusion. In fact, the conversion of the scores into percentages clearly indicates that response accuracy at the highest level of ambiguity is not significantly different from chance. In other words, the subjects might have obtained the same score if they had guessed.

With regard to the questionnaire results, only a brief comment will be necessary. Although the percentages were not significantly different from each other, the downward trend of Row 2 and the upward trend of Row 3 suggest that subjects in Group III were mainly concerned with retracing the image while subjects in Groups I and II spent their time groping for the correct nonsense syllables. Attention is also called to the apparent contradiction in comparing Rows 10 and 15. This contradiction suggests that the common belief, "first impressions are the best," had not been altered during the experimental procedure.

Briefly then, here are the conclusions:

1. The effectiveness of a time delay is dependent upon the ambiguity of stimulus field. As the stimulus field becomes extremely complex, extra time is needed by the observer to approach and exceed chance expectations. The first hypothesis is largely infirmed and was confirmed only as it applies to extremely ambiguous stimulus materials.

2. The ambiguity of the stimulus field is an important determiner of response accuracy. With each successive increase of ambiguity of the field, there is a corresponding decrease in response accuracy. The second hypothesis was, within the limitations of this experiment, fully confirmed.

3. Of the two suggested variables, ambiguity of the stimulus field has the larger effect on accuracy of recognition of a known form imbedded in that field.

With regard to the role of the two suggested variables in the examination situation, it remains to be established whether the psychological processes operating between exposure and response in the task set in this experiment are basically similar to those operating in certain examining situations. If future research reveals such a similarity, the following tentative conclusions suggested by the present results would be borne out: (1) The student should take more time to think about highly ambiguous questions before he writes his answers; (2) the instructor who prepares the examinations should exercise care to avoid questions which are highly ambiguous.

Recalling the design of the present experiment, an integration of the results with those of allied studies may be made. Such integration as may be effected has the limitations of the differences in materials, subjects, and procedures existing between the several studies reported.

Bruner, Postman and Rodrigues (2), in a recent paper, have assumed that perception can be analysed into a three-step process. The first step is an "hypothesis" which refers to the set of the individual or a selective tuning toward certain stimuli or events in the environment. The second step, "input of stimulus information" involves the characteristic cues that can be derived from the stimulus situation. And the third step, "confirming or infirming of an hypothesis," relates to the establishment of the hypotheses if a certain amount of appropriate information is present. If this critical amount of relevant information is not present the hypothesis

will not be established and an unstable perceptual field will result. This perceptual field will become stabilized when the individual, after altering his hypothesis by checking its agreement with incoming information, either confirms a final hypothesis or reports, "I can't make it out." Thus an individual either confirms an initial hypothesis or develops successive ones which agree with the information he has at hand at the time of making his response.

The strength of an hypothesis varies. "The greater the strength of the hypothesis, the less the amount of appropriate information necessary to confirm it. The strength varies with many conditions such as past use, past success, and the degree to which it dominates." (2) The amount of appropriate information given to an individual in a perception experiment can be varied by altering exposure or illumination of the stimulus field.

The appropriateness of information can be determined by independent test to discover what cues of the stimulus field are useful in confirming or infirming an hypothesis.

This is the essence of the theory. The proposition which Bruner experimentally tested and proved was that an initial hypothesis would be confirmed if the individual received a small amount of appropriate information, or stated inversely, with greater amounts of appropriate information initial hypothesis is likely to be infirmed with alternate hypotheses formed to agree with incoming information.

Since Bruner's experimental design was not similar to that in the present study his results will not be discussed here. Instead, at this time, the present experiment will be described in terms of the above theory.

First the hypothesis: The hypothesis that the forms which the subjects had previously learned were imbedded in a figure that they would see.

was given to each subject of each group as part of the experimenter's instructions. The subject could also entertain any of four sub-hypotheses (i.e., this is going to be a TOZ, a FIK, a HEB, or a DEZ) just prior to the exposure. It is assumed that the strength of such hypotheses do not differ significantly.

Now with regard to amount and appropriateness of information, these two variables can't be distinguished clearly in the present experiment. They seem to co-vary perfectly in what may be called a net amount of appropriate information as reflected in the ambiguity measure. This net amount of appropriate information is highest in the least ambiguous figures and lowest in the most ambiguous ones, and may be understood as follows: Figures at all levels of ambiguity contained the basic forms as a minimum amount of information. The most ambiguous figures, in addition to the forms, contain such irrelevant and misleading "information" as extra lines; thus there is a low net amount of appropriate information. The least ambiguous figures, on the other hand, contain relatively few extra lines--less irrelevant information--in addition to the form as the basic minimum; here there is a high net amount of appropriate information.

Now to use Bruner's terminology, what happens to the initial sub-hypotheses as the net amount of appropriate information input varies? And how is this information transformed over varying periods of time to give rise to a final hypothesis just prior to making a response? In the present experiment it was expected that the greater the net amount of appropriate information input, the closer would the subject's hypothesis be in agreement with objective reality, and that with time the net amount of appropriate information would give rise to hypotheses in successively closer accord with the facts.

The first expectation was clearly confirmed--all differences along the ambiguity continuum were significant. The second expectation was largely denied and was only in part confirmed--the time delay variable was effective only when ambiguity was high (net amount of appropriate information was low).

To interpret these findings in terms similar to Bruner's, the time delay variable will be disregarded since it does not correspond with any of Bruner's terms and is not an important variable. However the results of the present experiment concerning the ambiguity of the stimulus field bears out Bruner's proposition that with a small net amount of appropriate information, an initial hypothesis will be confirmed. At the highest level of ambiguity (net amount of relevant information is low), the subjects named the correct form purely on a chance basis. Thus, although the subject knew that one of the four forms was contained in the figure or stimulus field, there was not enough information to infirm any particular sub-hypothesis in favor of another and the subject had no recourse but to confirm one of them by just guessing blindly.

The opposite was true at the lowest and intermediate levels where the net amount of appropriate information is higher. In this case, the subjects exceeded chance expectations in naming the correct form. They were able to infirm three of the sub-hypotheses in favor of one that agreed with information which emanated from the exposure of the stimulus field (input of stimulus information).

If this speculative interpretation is correct, the results of the present study lead support to Bruner's conception of judgment processes of the type encountered in the present experiment. Further research is needed, of course, to establish definitely both the congruence of Bruner's theory with these findings, and to investigate the generality of that theory.

Several studies have been concerned with the relationship between exposure time and accuracy of response.

Phillip (9) was interested in finding the relationship between the amount of exposure time and accuracy of response in a perceptual task. The task was to name the predominating color when a card, on which a series of colored dots were printed, was exposed for various lengths of time (.133, .200, .299, .477, or .668 seconds). The cards represented five levels of difficulty which may be seen as similar to the present notion of "levels of ambiguity." The easiest cards had 12 dots of one color and six, six, and six dots respectively of three other colors; then 16 dots of the predominating color and seven, seven, and six of the other colors; then 14 dots of the predominating color and seven, seven, and eight of the other colors; then 12 dots of the predominating color and eight, eight, and eight of other colors; and finally the most difficult cards had 11 dots of the predominating color and eight, eight, and nine of the other colors.

Phillip's results indicate the same relationship as found in this experiment between accuracy of response and ambiguity of the stimulus field when exposure time was held constant: as the ambiguity ("difficulty" in his terms) of the stimulus field increased, response correctness decreased. Phillip also found that within a given level of difficulty, variations in exposure duration were (within his limits) not sharply related to response accuracy. This again, is in accord with the present findings of the relative ineffectness of time delay (though it should be noted that Phillip's time variable was of exposure rather than delay of response after fixed exposure).

Gundlach, Rothschild and Young (5) are the only investigators who have experimentally tested "set" in approximately the sense as it has been

defined in this study. They assume that "the complexity of an instruction which a subject is capable of apprehending and executing indicates his capacity to become temporarily set." However, in their experimental approach, verbal instructions were eliminated in favor of the visual presentation of lights which were flashed in certain orders and patterns on a panel in front of the subject. The rate of flash occurrences was altered, resulting in a variation of total observation time. Only five lights were used in any combination. Observation time varied, after ten trials on a given order or pattern from .10 second up through and including one second, in intervals of .10 seconds. The subjects were required to point out the positions of the lights after the last light had flashed. "The flashing of lights, under the general instruction to indicate the sequence by pointing, presents a problem to the subject which sets him in a particular manner. This set conditions his subsequent pointing movements." (page 275) Thus the correctness of response, pointing out the correct sequence, is dependent upon the set (constellation of determining factors) at the time the response is made.

It may be noticed that Gundlach et al also carried out their investigation of set as a perceptual problem.

Their results show that with decreasing exposure times of the lights, the accuracy with which the subject pointed to the position of the lights also decreased. These results are comparable to those in the present study only in so far as variations in durations of light exposures may be interpreted as "levels of ambiguity."

It was originally thought that the two variables, ambiguity and decision time, would produce results similar with respect to their relative effects on accuracy of response to those obtained by Woodrow (10). Woodrow was

interested in discovering the length of fore-period which would result in shortest reaction times. Woodrow's experiment, in which the subject was required to respond to an auditory stimulus as quickly as possible, used two conditions. In one condition, the length of the fore-period (between the "ready" signal and stimulus) remained the same throughout a series of trials which allowed the subject to adjust to it. In the other condition, the length of the fore-period was varied irregularly and without warning.

Woodrow found that when the length of fore-period was held constant throughout the series, the duration of fore-period needed for fastest reaction time could be definitely established by the subject at two to four seconds. However, when the fore-period varied irregularly and without warning no clear optimal length of fore-period could be established. It can be seen that Woodrow's different conditions provided differently ambiguous instructions to his subjects, and that when ambiguity was high, reaction time (which viewed as response efficiency, is similar to correctness of judgment in our experiment) was generally less rapid and less stable. In terms of the present experiment, Woodrow's results show that a given time delay (fore-period) was effective in producing the greatest number of correct responses only when ambiguity of the subject's instructions was low.

This section may be concluded by stating that the findings of this study seem to be paralleled and to some extent corroborated by other experiments bearing on the present problem. However, the main value of the present experiment was to afford a specific test of two hypotheses and perhaps to offer suggestive evidence concerning the practical problem.

Obviously this experiment has left several issues unsettled. What effect would longer or shorter decision times have on the accuracy of response? Would a point be reached where any increase of decision time would result in a decrease in response accuracy at all, including the highest, levels of ambiguity? We would reply in the affirmative in answering this last question, since it might be possible that wrong responses once eliminated might be reinstated and given as an answer as the recollection of the stimulus figure became less and less clear. Moreover, it might also be expected that at some point the nonsense syllable names of the forms would tend to become forgotten.

As for a shorter time delay, a zero time delay might be investigated. It is entirely possible the subjects might have made a higher score if they had been allowed to give their answer immediately, especially at the middle and easiest levels of ambiguity. However, on the basis of the findings concerning the other groups it would be predicted that subjects who were required to give their answers immediately would fall below the scores obtained by the two second group. It should also be remembered that our results argue against relying on first impressions or "hunches."

As an after thought, and not as a part of the experiment as originally planned, it was decided to test the above prediction. Thirty-six new subjects were assigned to a fourth, or zero delay group, equated with the other groups in respect to sex, age, and intelligence scores. This group differed from the others in mean number of trials to learn the paired associates.⁸ The subjects were required to undergo the same experimental

⁸ Although the subjects in this group were required to learn the forms to the same criterion as the other groups, they learned the forms faster than the other groups and thus did not get, on the average, as much overlearning. Probably this lack of initial comparability was due to recent experience in a paired associates learning situation as part of another experiment concurrently being run.

procedure as the other groups, but were instructed to give their answers immediately. Actually "immediately" meant within one-half second since some time was needed by the subjects to vocalize their response. The results of this group are given in Table 8.

Table 8

Means and Standard Deviations and Percents and Standard Errors of Percent of Correct Responses

Ambiguity Level	N	M	S.D.	N	%	S.E.	%
1	36	1.72	1.02	144	43	4.12	
2	36	1.11	0.88	144	28	3.74	
3	36	0.19	0.40	144	4.9	1.82	

At all ambiguity levels, both the mean scores and the percentage scores are significantly different from those of the other groups at the .01 level. (See Tables 5 and 6.) Our prediction is clearly confirmed. These results also seem to indicate that within the limits of this experiment, working at top speed results in a large decrease in accuracy. It should be understood that the validity of this conclusion may be slightly qualified by the difference in mean number of trials to learn the name of the forms, and hence in overlearning of this group from the others.

SUMMARY

This study may be summarized as follows: Two variables, decision time and ambiguity of external stimulating conditions, were suggested as factors operant in examination situations which might affect the adequacy of an individual's set at the time of writing his answer. Set, here, refers to the constellation of determining tendencies existing at the time of response. With set so conceived, the problem was then treated in the experimental laboratory as one of perception: "How does the student perceive the question at the time of his response?"

The perceptual task was the recognition of a previously learned geometric form. Two hypotheses were proposed for experimental testing:

1. Other factors being equal, the accuracy with which a known form may be recognized when imbedded in the context of other lines will vary with the amount of time available for report.

2. Other factors being equal, the accuracy with which a known geometric form may be recognized when imbedded in a context of other lines will vary with the ambiguity of the external stimulating conditions.

To test these hypotheses the following procedure was used:

1. In a preliminary experiment to determine ambiguity of external stimulating conditions, 30 subjects learned, using a memory drum and paired-associates method, nonsense-syllable names of ten visual forms. Forty differently complex Gottschaldt-type figures containing one of four experimental forms (out of the original ten) were then exposed tachistoscopically for .33 seconds, with instructions to name which of the ten original forms was imbedded. Using as a basis the percent of subjects correctly identifying the form, one figure at each of three distinct levels of ambiguity for each of the four forms was chosen for later use.

2. In the main experiment, three equated groups of 36 subjects each learned, by the same method as above, nonsense-syllable names for the four experimental forms. Twelve figures, four at each of the three defined ambiguity levels, were presented tachistoscopically to all subjects. Groups I, II, and III delayed naming the imbedded form for 2, 4, and 6 seconds respectively, until E's signal. A fourth group, instructed to respond immediately after the exposure, was added later.

The first hypothesis was tested by comparing the means and percents of correct responses of the different groups to figures within each level of ambiguity. The second hypothesis was tested by comparing the means and percents of correct responses within each group in response to stimulus fields of different levels of ambiguity.

The result indicated that while response accuracy varied inversely with the ambiguity of the stimulus field, decision time was an effective determinant of response accuracy only at the highest level of ambiguity. The ambiguity factor is shown in general to be the more important, although the distracting effects of highly ambiguous stimulus information may be lessened by increasing the amount of decision time. Decision time in excess of two seconds was of no value when the stimulus information was of low or intermediate ambiguity.

Some very tentative conclusions regarding the role of these two variables in the practical examining situation, qualified in recognition of the differences between that situation and the experimental one, were suggested.

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