Table 17

ANOVA: Trend Analysis on Visual Search for Bottom Quartile Group (n=14)

Source	df	MS	F	P
Between	3	49.82	7.94	.000
Linear	1	108.90	17.35	.000
Dev. from Linear	2	20.29	3.23	.047
Quad	1	5.33	0.85	.361
Dev. from Quad.	1	35.24	5.61	.021
Within	52	6.28		

On the other hand the group scoring low on the planning dimension behaved differently across trials. An analysis of variance (repeated measures) and a trend analysis on the bottom quartile subjects are reported in Table 17. A significant main effect for trials was found (F=7.94, df=3.52, p<001). The trend analyses for the low group also revealed a significant linear component (F=17.35, df= 1/52, p<001) and a significant deviation from a quadratic component (F=5.61, df=1/52, p<001). A further calculation revealed that the deviation from the quadratic can be explained by a significant cubic component (F=9.77, 1/52, p<001). A visual inspection of Figure 1 appears to confirm these statistical findings. Finally the Newman-Keuls test between means for this group revealed a significant difference (p<.01) between trials 1 and 2, 1 and 4, but not between 1 and 3, 2 and 3, or 2 and 4.

These findings suggest that subjects scoring low on the planning dimension do not reach asymptotic performance in this visual search task. The significant linear and cubic components found in their scores across trials suggest an improvement from trial 1 and 2; a levelling off between 2 and 3, and subsequent improvement from 3 and 4. This suggests that subjects in this group learned a strategy and utilized it between trials 1 and 2, but not between 2 and 3, and then utilized it between trials 3 and 4. Finally in view of the strategy manipulations demonstrated by the experiment it appears that this group did not utilize the strategy proficiently across trials. In fact one may question whether this group in fact learned how to utilize strategies in a consistent manner.

These results confirm our expectations that subjects scoring high and low on this planning dimension would differ in performance across trials. Specifically that they would differ in terms of their utilization and proficiency in adopting the clockwise and counter clockwise strategy manipulations inherent in this visual search task. It was predicted that the high planning group would learn the strategy, plan and use it proficiently as demonstrated by their reaching relative asymptotic performance by the second trial. Similarly it was predicted that the performance of the low planning group would demonstrate considerable variability across trials, thereby not reaching asymptotic performance, and suggesting an absence of learning the appropriate strategy manipulations. Earlier theoretical explanations suggest that this group exhibited deficits in planning.

Trail Making: Results

In the second experiment involving the Trail Making Task, elapsed time was measured for each subject, for Parts A and B. The scores were averaged from all subjects between first and second half of the task, and submitted to a Two-Tailed test of significance of mean differences. A significant mean difference was found for Part A ($t=6.31$, $df=54$, $p<.001$) as well as for Part B ($t=6.88$, $df=54$, $p<.001$). This result confirmed the prediction that subjects would demonstrate a decrease in elapsed time from the first half to the second half of each part of the Trail Making task.

The total scores from each subject were summed across Parts A and B and rank ordered to extract top and bottom quartiles. The scores on Part A and B for the two groups was then submitted to a 2 (groups) x 2 (parts) x 2 (halves) and analysis of variance repeated measures. The results in Table 18 reveal an expected significant main effect between groups ($F=143.10$, $df=1/52$, $p<.001$), between Part A and B ($F=10.91$, $df=1.52$, $p<.002$) and between the first and second halves of the tasks ($F=21.77$, $df=1/52$, $p<.001$). The mean elapsed time for the two groups, on Parts A and B, and between first and second halves of the task are reported in Table 19.

In order to determine more specifically the nature of the group differences on <u>each</u> part of the Trail Making task further analyses were carried out.

Part A

The scores on Part A for the two groups were submitted to a 2 (groups) x 2 (halves) analysis of variance repeated measures. The results in

Table 18

ANOVA repeated measures on Trail Making-Part A & B

for top and bottom quartile groups (n=28)

Source	df	MS	F	P
Between				
Group	1	95.83	143.10	0.001
Part (A&B)	1	7.30	10.91	0.002
Group x Part	1	2.29	3.33	0.074
Error	52	0.67		
Within				
Halves	1	10.44	21.77	0.001
Group x Halves	1	1.16	2.42	0.126
Part x Halves	1	0.04	0.07	0.786
Group x Part x Halves	1	0.97	2.01	0.162
Error	52	0.48		

Table 19

Means and Standard Deviations of

Trail Making Experiment for Top and Bottom Quartile Groups (in sec.) (n=28)

Variable	Mean	Standard Deviation
Part A		
Top-First half	3.24	.57
-Second half	2.58	.42
Bottom -First half	4.79	.91
-Second half	4.16	.96
Part B		
Top-First half	3.62	.66
-Second half	2.66	.55
Bottom -First half	5.36	.85
-Second half	5.18	.95

Table 20 reveals a significan main effect between groups ($F=11.24$, $df=1/26$, $p<.002$). Finally, the result of note is the interaction effect found between groups x halves ($F=17.63$, $df=1/26$, $p<.032$), suggesting that the high and low planning groups behave differently in their performance from the first to second half in this task. The means for the groups are plotted in Figure 2. A two-tailed test for the high group means reveals significance ($t=2.31$, $df=13$, $p<.05$), however, such is not the case for the low group means. This may suggest that subjects scoring high on the Trail Making test in all likelihood established a strategy and utilized it proficiently. The subjects scoring low on the Trail Making test, on the other hand, appeared not to see a pattern developing in the task or did not exercise a strategy proficiently. These statements are hypothetical, but confirm theoretical explanations advanced on the planning dimension.

Part B

In Part B of the Trail Making task the top and bottom quartile scores were extracted and the data submitted to a 2 (groups) x 2 (halves) analysis of variance repeated measures. A main effect was observed between groups ($F=60.06$, $df=1/26$, $p<.001$), and between first and second halves ($F=10.68$, $df=1/26$, $p<.003$). However, the analysis which is reported in Table 21 did not reveal an interaction effect. That is, the two groups were not significantly different from the first to second half in terms of improvement of elapsed time. This result is not consistent with the hypothesized prediction. An explanation might be that although the low group scores were higher (see Figure 3) this group did, in fact, recognize a pattern developing, thereby utilizing a strategy in this task, making improvement earlier and maintaining this improvement.

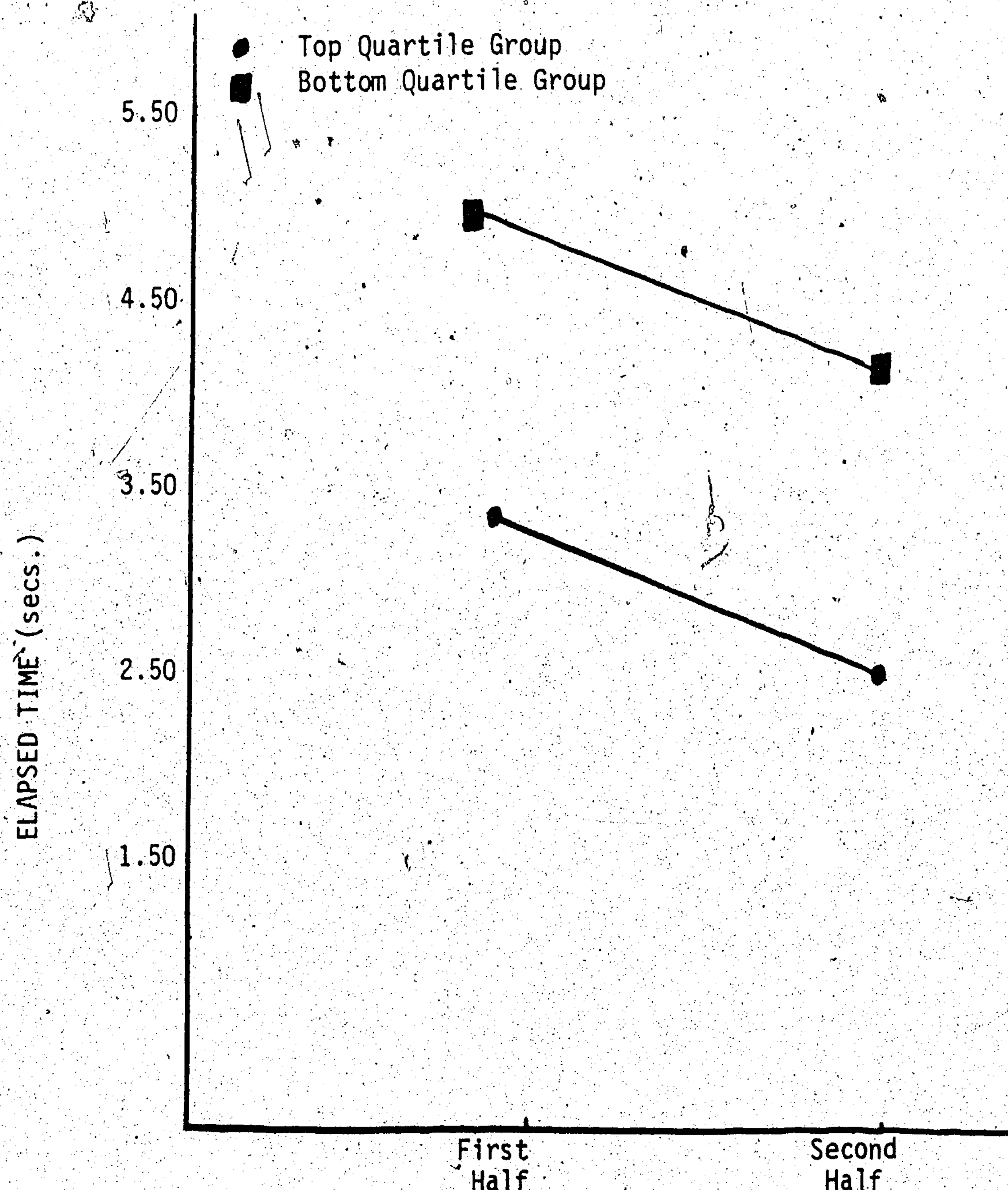

Figure 2. Elapsed time means of groups x halves (Trail Making-Part A)

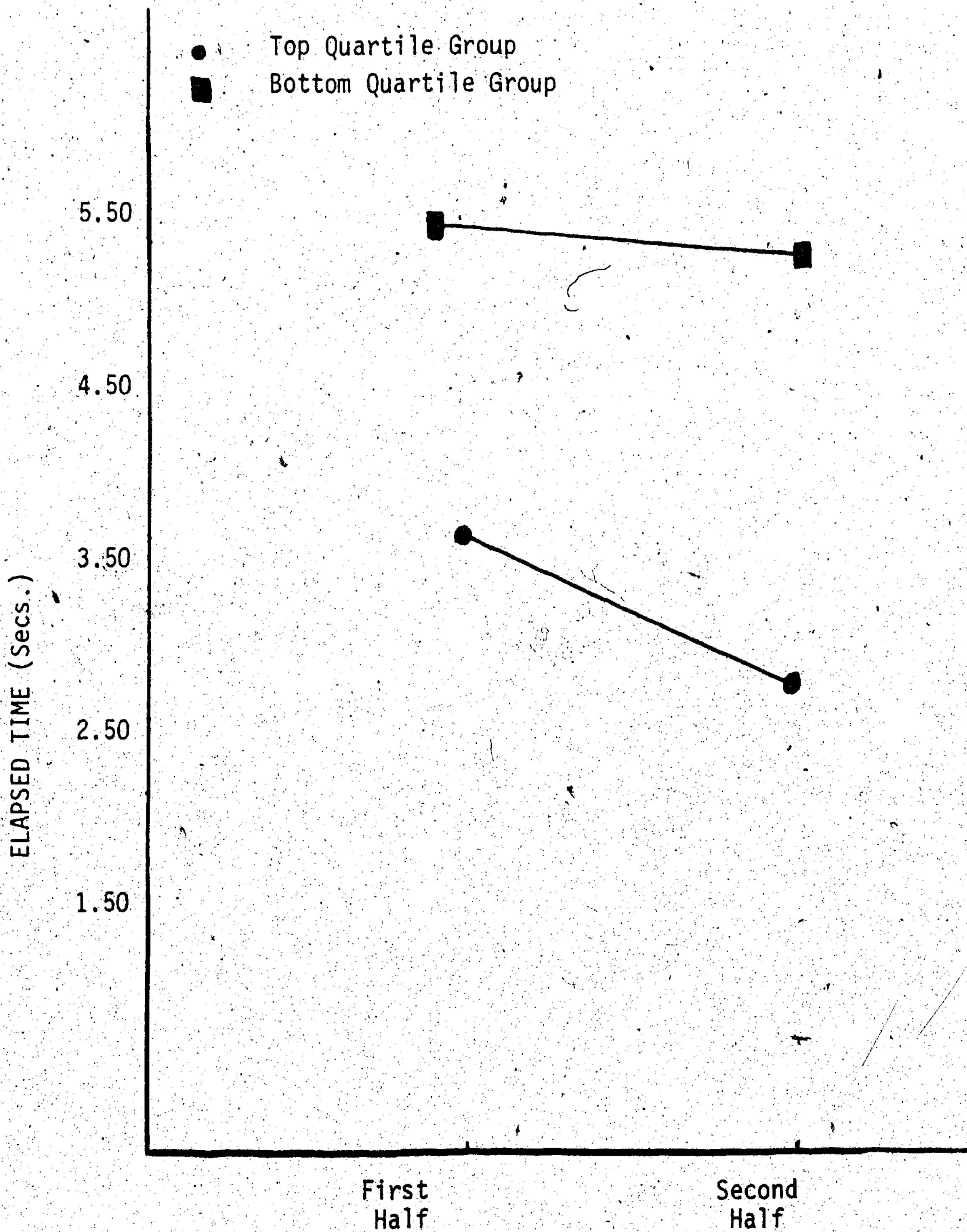

Figure 3. Elapsed time means of groups x halves (Trail Making-Part B)

Table 20

ANOVA repeated measures on Trail Making PART A

for top and bottom quartile groups (N=28)

SOURCE	df	MS	F	P
Between				
Groups	1	63.64	83.04	.001
Error	26	.77		
Within			11.24	
Halves	1	4.63	5.15	.002
Groups x Halves	1	2.12		.032
Error	26	.41		

Table 21

ANOVA repeated measures on Trail Making - Part B

for top and bottom quartile groups (n=28)

Source	df	MS	F	P
Between				
Groups	1	34.41	60.06	.001
Error	26	.573		
Within				
Halves	1	5.85	10.68	.003
Groups x Halves	1	.004	0.008	.929
Error	26	.55		

CHAPTER V

Study 3: Problem Solving

In our earlier discussion of planning and problem solving, it was suggested that the executive function of cognition is activated in problem solving, specifically that problem solving tasks are able to demonstrate the role of planning in higher-order thought processes.

As previously mentioned the cognitive process of planning was discovered by utilizing the Visual Search (VS) task among others (Ashman, 1978). Having already demonstrated that the VS task has high loadings on a factor of planning which was orthogonal to coding: that it reflects individual differences; and is susceptible to stategy manipulations, it remains to be seen if individual differences on this measure would relate to differences which involve higher-order problem solving. One would predict this to be the case, that in fact the cognitive process of planning evident in a VS task, would also be evident in a higher-level problem solving task. Subsequently, one could expect high and low performance levels on one task would also be evidenced on the other. Furthermore, low performance on a problem solving task should reflect a deficit in planning and strategic behavior.

Solving a problem involves organizing and structuring information which activates planning and coding functions. In order to solve a problem, the subject must be able to know what is required in the task, have a plan or strategy <u>by</u> and <u>on</u> which to operate, have an orientation or attitude set which will facilitate working towards a goal, be able to control and regulate behavior according to the plan, and finally, verify that the intention of the plan is carried out.

As pointed out previously low scores on tasks measuring planning behavior may be due to any or all of the following: the inefficiency of realistic self-evaluation performance, a failure to monitor, check and register ongoing behavior, inefficient use of control processes, ineffective strategic transformations of input, and a lack of feedback to response correcting behavior. In short subjects generally deficient in planning demonstrate inadequate higher-order information processing skills.

In this study, the problem solving behavior of good and poor 'planners' as indexed by their visual search scores, is examined.

The specific objectives of this study are:

1. To investigate the relationship of subjects' scores on two tasks involving planning behavior, one primarily involving visuo-perceptual functioning and the other logico-rational functioning.
2. To explore the qualitative differences in the strategies utilized for problem solving between the good and poor 'planners.'

Hypothesis

The hypothesis is advanced to attempt to test the generality of the assumptions of the cognitive process of planning, by examining the relationship between scores on a Visual Search task and a higher-order problem solving task (Mastermind Game).

It is anticipated that subjects scoring in the top and bottom quartiles on the VS will differ significantly in performance on Mastermind. Specifically it is predicted that subjects scoring high on the VS will take fewer trials to solutions than those scoring low.

Method

Subjects

Sixty first year students enrolled in four programs at a community college acted as volunteer subjects. These programs typically draw students from a cross-section of socio-economic status. The students ranged from 18 to 30 years in age, and had a mean age of 22.42. The sample comprised an equal number of males and females.

Tests and Procedures

The two instruments used were the standard version of the Visual Search task and the Mastermind task. The VS was administered to all subjects. Subsequently, the top and bottom quartile scores were extracted leaving a sample size of 30 subjects. These subjects were then administered a Mastermind task.

1. Visual Search Task

The standard version developed by Ashman (1978) was used in this study. In this task subjects were required to search for a duplicate match of a target figure. The matching figure was embedded among geometric, letter and numerical shapes in a field.

Each field was constructed on an overhead transparency and then inserted in the Visual Search viewing apparatus. The apparatus permitted accurate timing of the subjects search time in locating the duplicate match of the figure. A description of the procedure, and a copy of a field are in Appendix A.

2. Mastermind Task

This task was developed by Parker brothers, and involves problem solving strategies. It meets the criterion of being: "subject-matter free" and well structured. Davis (1973) defines a problem solving task as a stimulus situation for which an organism does not have a ready response. The Mastermind task fits this criterion.

In this task the experimenter set up a line of coloured code pegs (which were out of the visual range of the subject) in shielded holes located at the end of the de-coding board. The subject was required to duplicate the exact colour and position of the hidden code pegs set up by the experimenter. The 6 colour-4 hole version of the Mastermind task was used. The 4 colours making up the code for each trial were randomly selected by the experimenter, not allowing for 2 or more code pegs of the same colour. Three trials were given to each subject thereby reducing the likelihood that responses would be spuriously affected by chance factors. More trials may have been even more effective, however, limited time available to subjects did not make this possible.

After selecting the coloured code pegs (i.e. blue, brown, red, orange, green, yellow) each subject placed a row of four code pegs into the de-coding board. The experimenter then placed a black peg adjacent to the row if the subject had correctly chosen one of the colours and it was also located in its proper position. A white peg was placed if the subject had chosen a colour identical to one of the code pegs in the shielded holes, but had not placed it in the correct position. If the subjects peg did not match the experimenters in colour or position, the key peg holes adjacent to the row was left vacant. When the subject duplicated the hidden code in the shielded holes, the experimenter placed 4 black key code pegs.

The number of rows taken to break the code for each game or trial was recorded as was the amount of time taken to complete each row. The instructions and hidden colour coded pegs for the three games or trials are found in Appendix J. Finally any verbalization given by subjects during the task were recorded.

Results

The scores of all 60 subjects on the visual search task were rank ordered and grouped into four hierarchical quarters or quartiles. The mean and standard deviations (in seconds) for each quartile group was then calculated and are reported in Table 22. The mean comparisons between the top and bottom quartile groups revealed significant differences ($T=9.81$, $df=28$, $p<.001$).

Table 22

Mean and Standard Deviation of Visual Search Tests for Quartile Groups for Total Sample (N=60)

	Means	Std. Dev.
1st Quartile Group	8.86	1.56
2nd Quartile Group	11.73	.51
3rd Quartile Group	13.86	.64
4th Quartile Group	17.35	2.97
TOTAL GROUP	12.95	3.55

The top and bottom quartile subjects were then required to solve the Mastermind Task. The row scores for each trial for the two groups, and the time per row scores for each trial are reported in Table 23. These scores were then submitted to a 2(group) x 3(trials) analysis of variance, repeated measures. Table 24 indicates an expected significant main effect for groups ($F=9.25$, $df=1/28$, $p<005$). The same analysis did not yield a significant main effect for trials, or the interaction between groups and trials. This was also expected in that subjects did not differ significantly between trials indicating perhaps that the task measured differences consistently.

The time per row scores were also submitted to a 2(groups) x 3(trials) analysis of variance, repeated measures. Table 25 indicates that no significant main effect for groups or trials was found. This suggests that in this task, time was not a variable that discriminated between the groups, and that solution time did not change significantly across trials.

Qualitive Analysis

As expected subjects scoring high on the planning dimension took fewer rows to break the code in the Mastermind task, than did subjects scoring low on the planning dimension. It would appear plausible to suggest that subjects scoring low on the visual search task exhibited more deficits in planning behavior than those scoring high, as evidenced by their performance in a complex problem solving task. It can only be speculated at this time why the groups differed in performance. However, the verbal reports

Table 23

Mean comparisons of Master Mind Row scores across 3 trials for two groups (N=30)

Variable	High 1	High 2	High 3	Low 1	Low 2	Low 3
Rows	6.46	5.40	5.20	9.67	8.73	9.27
Time/Row (Sec.)	52.56	51.80	51.87	53.14	59.68	56.09
Total Rows		17.06			26.45	
Total Time (Sec)		937.00			1721.33	

Table 24

ANOVA repeated measures for Master Mind Rows across trials for two groups (N=30)

Source	df	MS	F	P
Between Groups	1	280.89	9.252	.005
Error	28	30.36		
Within Trials	2	8.61	1.05	NS
Groups x Trials	2	1.63	.209	NS
Error	56	8.19		

TABLE 25

ANOVA repeated measures for Master Mind Time
across trials for two groups (N=30)

Source	df	MS	F	P
Groups	1	401.78	.130	NS
Error	26	3091.13		
Within Trials	2	63.63	.121	NS
Groups x Trials	2	100.11	.190	NS
Error	56	525.69		

of subjects recorded during the problem solving task may provide some clues. These records also provide data for further exploration in terms of the planning dimension. The records indicate a distinct set of personality and cognitive differences between these two groups.

(a) Superstitious Behavior

In terms of personality differences, some of the low level problem solvers engaged in superstitious behavior as evidenced by the following responses:

"red was good to me last time."

"people usually prefer brighter colours."

"I don't like dull colours."

(b) Value of Reasoning

Bloom and Broeder (1974) in examining lower aptitude students also found that they are "inclined to take the view that in solving problems, reasoning is of little value and that either one knows the answer to a problem at once or one does not." (p. 21).
A similar attitude was in evidence in this study with the low level problem solvers. Several subjects made the following responses:

"there must be a trick to this."

"I can't do this kind of thing, it doesn't make any sense."

"I've just about tried everyone of these colours already."

Bereiter and Engelman (1974) also point out that low aptitude subjects usually believed that "answers had to be grasped at once, or they were inaccessible." (p. 34).

(c) Use of Feedback

The problem solving approach exhibited by those scoring low on the planning dimension is further illustrated by their placement of pegs during the game. Some subjects would appear to be fixated on a certain singular colour and would continue using it in spite of the negative feedback, which indicated its inappropriateness. Similarly, subjects used the identical colour combinations and positions several times within one trial, indicating a lack of effective monitoring and checking strategies. A general lack of systematic strategic behavior was found to be present in low problem solvers.

Underwood (1978) in discussing strategies notes that limits on the ability to perform a task effectively are threefold: failure to use the appropriate strategy, inadequate proficiency and limited capacity. It is unlikely that subjects had difficulty due to limited capacity; however, our records do indicate inappropriate and/or an absence of strategic behavior. Feedback from the experimenter is given after each row placed by the subject, however subjects who are low in problem solving skills do not adequately recognize or utilize the feedback, since they do not shift their responses. Planning is certainly involved in the selection of strategies. In this particular task, the effective strategies are: formulating hypotheses, exploring alternatives, monitoring feedback and finally, verifying and rejecting hypotheses. There is very little evidence from observation or the verbal reports of poor players in Mastermind to indicate the presence of these strategies.

The approach to problem solving taken by the subjects scoring high on the planning dimension is distinctly different. These subjects demonstrated evidence of the appropriate formulation and utilization of strategic behavior. Several subjects would place colours not used in their row next to the board as a visual reminder and would discontinue the practice when the colour code had been broken.

(d) Presence of facilitatory vocalization

Another index of strategic behavior described by Flavell (1970) and confirmed in observation in this study is the presence of vocalization during presentation of items. One subject responded "I'll have to start talking to myself. I find it helps." This group also appears to benefit from feedback as evidenced by this remark: "I won't make that mistake again in the next row." The subject is obviously monitoring and checking his behavior. The high group also demonstrated the recognition of the utility of prior knowledge: "This reminds me of a math course I took, it involved permutations." Underwood (1978) has termed this behavior as relatedness search in which the subject searches in memory for items related to a given stimulus situation.

In conclusion, the evidence of strategic behavior provided by cognitive learning theorists suggest that perhaps there is one strategy or master plan which facilitates the acquisition and use of all other strategies. Evidence of higher order strategy is best exemplified by a response made by a subject in the high planning group. "Now I've developed a strategy. First find the colours---by process of elimination. I place each colour next to the board for reference. I just can't play a game without understanding the systems involved."

CHAPTER VI

Summary & Conclusions

The basic purpose of this research was to explore the planning function of adults within an information processing framework. The strategy employed towards that end involved the selection of tasks, especially those which had been used to test frontal lobe functions, postulated by Luria to be responsible for the planning and programming of behavior. Luria used the clinical method to derive a set of tests which defined a frontal lobe syndrome, and then used the common task demands in these tests to define the deficient cognitive process which in this case was planning. The purpose of these tests was to establish dysfunctions unique to patients with frontal lobe damage. The final battery of tests for planning was determined by factor-analytic work, and the invariance of the planning factor was established across groups with normal and subnormal intelligence. (Ashman, 1978; Das, 1980).

For the purposes of the present study, especially in Study 2, the battery of planning tasks was modified and a new task (syllogistic reasoning) was added. Correlational and factor analyses were then constructed to determine the relationships among the tasks. These procedures resulted in a set of tasks which were fairly reliable, statistically independent, purported to possess construct validity, and consistently provided measures of individual difference.

Secondly a number of experimental "treatments" were built into the study to extend the theoretical underpinnings of the selected tasks, thus allowing for stronger interpretations of the planning dimension under study.

Thirdly, analysis of variance techniques were used to isolate potential individual differences in planning dimension. In summary, the primary question addressed concerned:

(i) the replicability of previous findings,

(ii) the use of additional tasks, to measure the planning functions;

(iii) the induction of treatments to extend theoretical formulations; and finally the adequacy of one of the planning tasks

to predict competence in a complex problem solving task such as Master Mind.

Replication of the Planning Factor:

In order to distinguish the coding function from the planning function all planning tasks were factor analysed along with the battery of tasks previously found to describe simultaneous and successive processing.

The principal component factor analyses established planning as an orthogonal factor to coding. The statistical analyses as such did not establish the independence of these processes. The independence of planning from coding came from theoretical formulations of the information integration model of Das et. al (1975) which has as it's basis the clinical work of Luria. Luria established functionally independent cortical areas for the cognitive processes of planning and coding.

These results replicated the findings of Ashman (1978) and thereby appear to re-affirm the identification of planning as a cognitive process as suggested by Luria's clinical observations of Block 3 functioning. The tasks found to consistently contain high loadings on a factor identified as planning were the Visual Search, Trail Making and Planned Composition.. Furthermore, the syllogistic reasoning time measure taken from the cogntive learning research literature also loaded highly on the planning factor.

Treatments

Results from the treatments built into the studies established consistent and stable differences between subjects scoring high and low on tasks previously established as measuring planning behavior. These treatments thereby extended the theoretical underpinnings of the selected tasks, thus allowing for stronger interpretations of the planning dimension.

Specifically training in the clockwise and counterclockwise strategies resulted in differential performance between groups scoring high and low on the planning dimension, thereby reflecting differences in utilization of the strategy and the proficiency with which it was used.

It can be hypothesized that the inability to successfully activate the appropriate planning functions required by the task in a similar study found evidence to support the notion that individuals low in problem solving ability had difficulty in using newly learned information to solve complex problems. Atkin postulated that this difficulty was due to "the inability to successfully activate the appropriate control processes (executive function) that resulted in low scores on problem solving."

It seems likely therefore that differential performance on tasks utilized in our study were due to planning differences. These differences are likely to occur at the stage of either choosing an appropriate plan or the efficient use of that scheme or program in carrying out the plan. In support of the latter, it has been suggested that poor performance can be explained in terms of ineffective sequencing of a plan. Specifically, it entails the inability to generate all successful steps in a plan, and an ineffective orientation towards the formation and execution of a plan.

<u>Complex Problem Solving</u> (Mastermind)

Having determined individual differences on a planning task derived from the clinical work of Luria, and found through factor analytic methods (Ashman, 1978, Das, 1980), the logical next step would be to determine whether performance on a planning task would relate to performance on a complex problem solving task. Our results support this predicted relationship.

Previous research reported earlier, has established that "higher level" cognitive processes are involved in complex problem solving. The existence of this executive functioning has been reported in the neuropsychological and cognitive learning research literature. In line with these our study discovered that subject's scores on a planning task were positively related to scores on a problem solving task. Therefore by inference it may be suggested that differences in problem solving can be attributed to planning differences. Furthermore, as suggested by Flavell (1978), Brown (1978), Sternberg (1979) and others, deficits in problem solving may originate in defective planning strategies. Observations reported in our study tend to support this notion.

It appears that one of the differences which may exist between high and low problem solvers, is perhaps the absence or presence of planfulness. It would appear plausible to suggest that the strength of this planning strategy distinquishes between these two groups.

In summary it appears that differences in complex problem solving performance may be due in part to the ability to initiate and maintain a plan of action. This finding is consistent with previous formulations of the information integration model of Das et. al (1975).

Limitations and Implications for Future Research

1. The utility of the third study is limited in that the indicators associated with planning control processes were obtained only in a very general manner. Although anecdotal records did provide evidence of differential strategic behavior, it could not be ascertained which specific strategies facilitated problem solving behavior. One might more directly establish the existence of planning functions by operationalizing its component functions and

train individuals in the usage of such in problem solving tasks.

2. The utility of the findings in our studies are limited in that planning as a higher-level cognitive process is diverse and complex in nature, and studies 2 and 3 are at best a modest advance in this area of research.

3. Finally a limitation of this study is that cognitive information processing differences alone may not be sufficiently sensitive to ascertain differences in performance on measures utilized. Therefore the inclusion of a number of personality and motivational factors would be recommended in future studies.

Implications for Research

One of the problems in research on higher-level cognitive processes is the diverse descriptors used to identify them (ie. metacomponents, executive, homonculus, control processes). In order to advance beyond this state of confusion it may be useful to attempt to theoretically and empirically identify a hierarchy of possible strategies involved which may differ in strength from person to person as Underwood (1978) has suggested. The author has speculated that "planfulness" may in fact be the "central strategy" in higher-level cognitive processing which may "facilitate the acquisition and use of all other strategies." (p. 441). Similarly, Brown (1974) has suggested that the strategy of constructing a strategy or "a plan to make a plan" may in fact be at the top of any hierarchy of strategic and intentional behavior. Brown and Campione (1979) in their work with moderately retarded groups have proposed that:

> "if one statement could summarize our conclusion it would be that it is not the presence or availability of the components of the target activity that is at fault in the retarded child, but rather it is the ability to select, modify, and sequence these components into an overall plan of procedure and evaluate the effectiveness of the approach selected. (p. 149).

Evidence of strategy differences in these populations has been provided and deserves further exploration. It is hoped following these leads that research into the nature of planning as a metacomponent and as an individual difference variable will clarify the notion of planning and ultimately lead to instructional programs to remediate deficits in planning behavior.

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APPENDIX A

Directions for the Visual Search Task

Testing procedure

The procedure followed for administration of the Visual Search task was the same for each subject in Study 2 and Study 3. The directions to testees were played on a cassette tape recorder, and were as follows:

"This is a test of how quickly you can find one pattern in a group of similar ones. We're going to use this box and electronic timers attached to it.

"I have a number of transparencies which I am going to place inside the box and when you turn the light on, you'll be able to see them through the red screen. But first, let me explain how to work the box.

"When you push down on the black switch, and hold it down, the light will come on and the timers will start. There is one rule you must remember, you must hold the button down or the light will go off. Try it. Push the button down and then take your finger off it and see what happens. (Pause) So to keep searching the transparency you must keep your finger pressing down on the black switch.

"There is another way to turn the light off. You can do that by Pressing down quickly on the red screen using the same finger you used to keep the black switch down. Let me demonstrate this for you. (Tester demonstrates) Now you try ~~it~~. Turn the light on then switch it off by pushing down on the red screen quickly. (Pause)

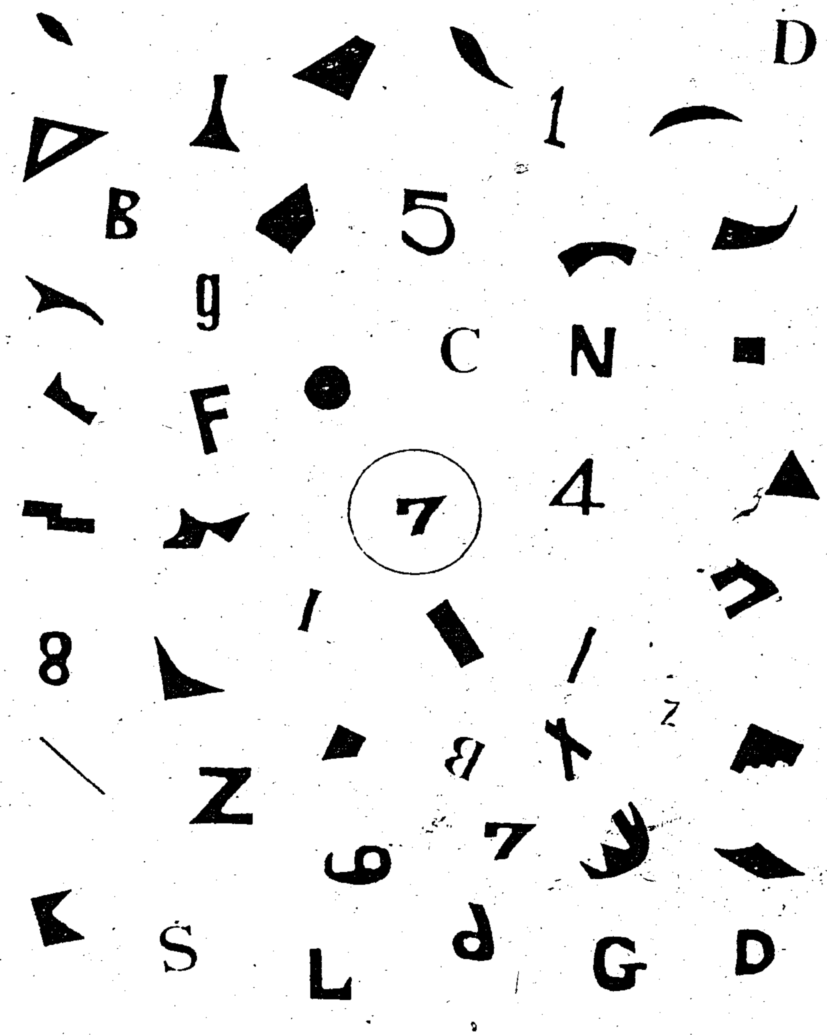
"Let me show you one of the transparencies. (Tester inserts a sample into the apparatus). This one has nine patterns on it which are letter, numbers and geometric shapes, plus a circle in the middle. On all of the transparencies there will be a copy of the shape which appears in the circle, somewhere else in the field. Your task is to point to the shape in the field which is exactly the same as the pattern you will find in the circle. Do this as quickly as you can when the light comes on. The shape you will be looking for is always different on each transparency, and is exactly the same as the one in the circle - it's never twisted around or distorted.

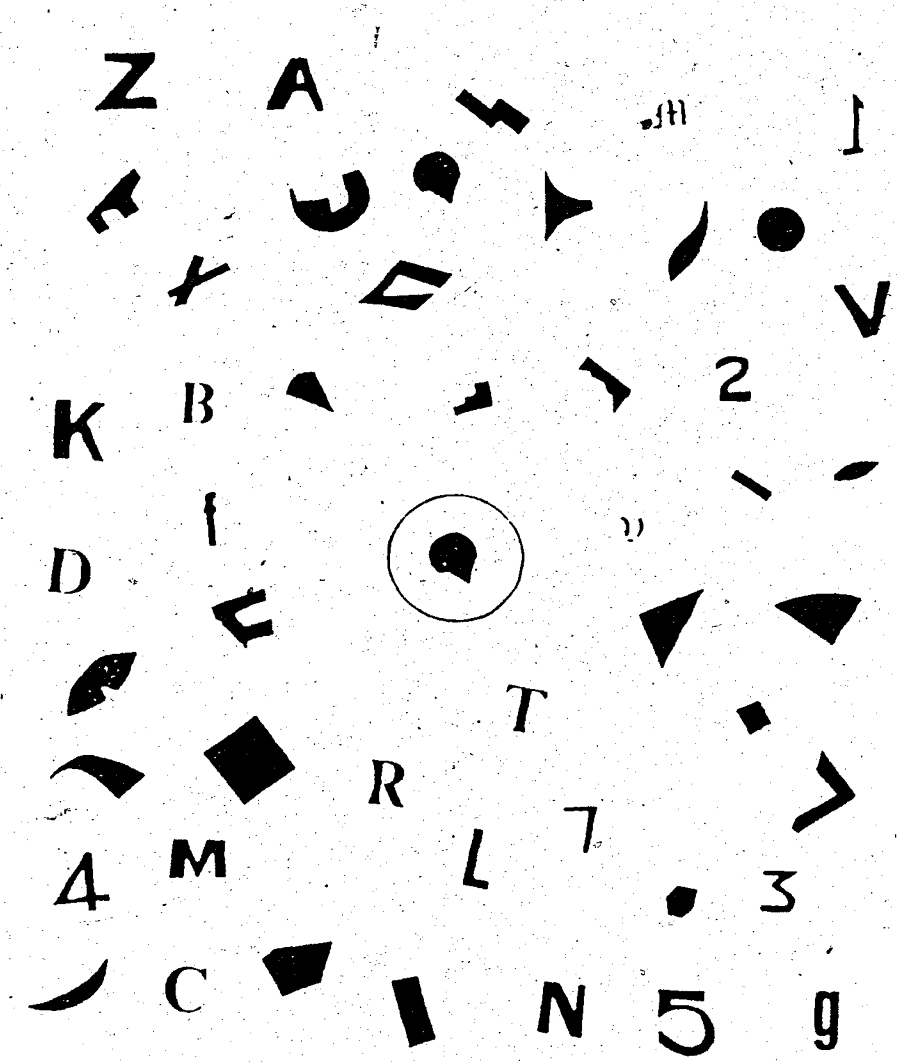
"Let us try a practice one, but first let me review the directions. When the transparency goes into the box, push down on the black switch and search for the copy of the shape you will find in the circle. Only when you have found the copy, lift your finger off the button and push down on the screen towards the copy. In effect you'll be pointing at the copy just below the screen.

"Are there any questions?" (Tester inserts practice transparency into the aparatus)

When the practice is complete, the tester resets the timers and places the first trial slide into the box. Transparencies were presented in random order, and times were recorded after each trial. The correlation between the two measures (Search Time and Response Time) was high (r=0.974, significant at the 0.005 level.)

Two Examples of Visual Search Transparencies (x 0.5)





APPENDIX B

Instructions for Visual Search Experiment

1. Sample Sets

A sample transparency was selected and shown to the subject without the aid of Visual Search Box Instructions were given as follows:

"I am going to show transparencies similar to this one, and each will have something in the centre of it (Experimenter points to stimulus target) I want you to find another one, somewhere else on the paper exactly like the one in the circle, and point to it. Go ahead."

The experimenter that subjects clearly understood the directions before demonstrating the operational procedure of the USB. The experimenter then continued as follows:

"I am going to demonstrate how this box will be used in helping you to locate the figures on the transparency. I'm going to put each transparency into the box like this (transparency placed within the slot, covered with a white sheet on top of it) Then I want you to press down on this button to turn the light on and hold the button down until you find one that is the same as the one in the center (the sample transparency already familiar to the subject was used). When you find the one you want, use the same finger to quickly press down on it (this will also turn the light out).

After having gone through one trial the subject was reminded of two important points.

1. The subject must keep the button pressed while searching for the target. The tendency is often to let go quickly, but since this will stop the timer, it was made clear that the subject was not to lift his finger until he is ready to press down (point to) the target.

2. The subject must use the same hand to press the button, and point to the target.

Between each trial, the experimenter pushed the reset button in order to set the timers back to zero.

In order to ensure that the subject was comfortable with the use of the VSB, two sample transparencies were used.

2. Training Sets

Following the sample sets each subject was given a clockwise (CW) or counter-clockwise (CCW) transparency. The order of presentation was altered from one subject to the next.

Assuming that the subject first received the CW set, the instructions verbalized by the experimenter continued. "See this transparency - it's divided into four parts. I'm going to show you four transparencies in a row, and in each one I want you to point to one which is the same as the one in the center. (Experimenter pointed out the target stimulus).

The subject was then asked "did the ones you pointed to come in any particular order?" The subject usually showed the experimenter or used the CW or CCW terminology to describe the sequential order.

Although further research into planning should be carried out, one of the problems in researching this area has been the difficulty in experimentally isolating the specific processes involved in planning. To that end Sternberg (1979) has devised two methods that may provide insight into planning behavior.

The first method is identifed as "structural precuing" and the second as "mixed-versus-blocked trials." In "structural precuing" two conditions are presented in which subjects receive varying amounts of information required for solving a problem. Subsequently subjects receive the full problem in the second part of each trial. The dependent measure which is labelled "strategy planning time" is attained by calculating the difference in elapsed time to achieve criterion between these two conditions. In the second method problems are presented either in blocked form or in mixed form. In blocked form, the trials involve problems with structures that are identical. However, the problems presented in mixed form vary in structure thereby requiring different strategies. The dependent measure also labelled "strategy planning time" is calculated "by subtracting for each subject mean blocked-trial time from mean mixed-trial time" (Sternberg, 1979, p. 261).

In regard to subject populations, continued investigation is necessary to establish group differences in planning behavior. Since the literature on age, retardation, and aptitude has established replicable and consistent cognitive differences, research must be expanded to include group differences between normals and retardates, adults and young children, and adults of differing intellectual levels.

If the subject did not recognize a specific pattern, the experimenter used the transparencies again, and drew attention to the pattern.

Once having established that the subject understood the notion of the pattern, the other Training set was administered in like fashion.

3. Test Sets

"Now we are going to use the machine again. Do you remember how?" At this point another sample was given and the instructions received.

APPENDIX C

Directions for the Trail-Making Test

Part A:

Look here. In this test your task is to draw lines between the numbers on the page in the correct order - from 1 to 2, from 2 to 3, from 3 to 4 and so on, until the end is reached.

"If you realize you have made a mistake, go back and cross it out quickly (you do not have to erase the lines) and then go on in the correct way."

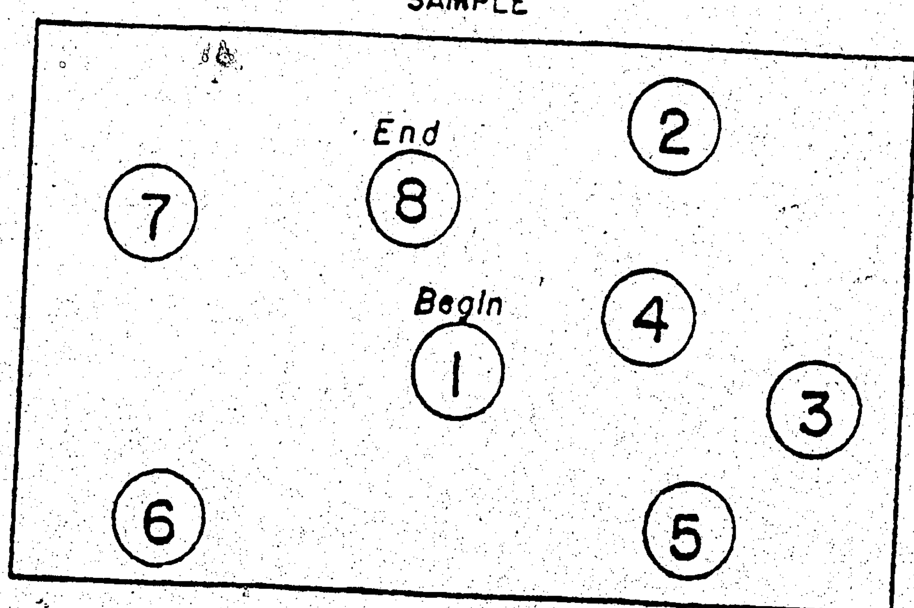
Part B:

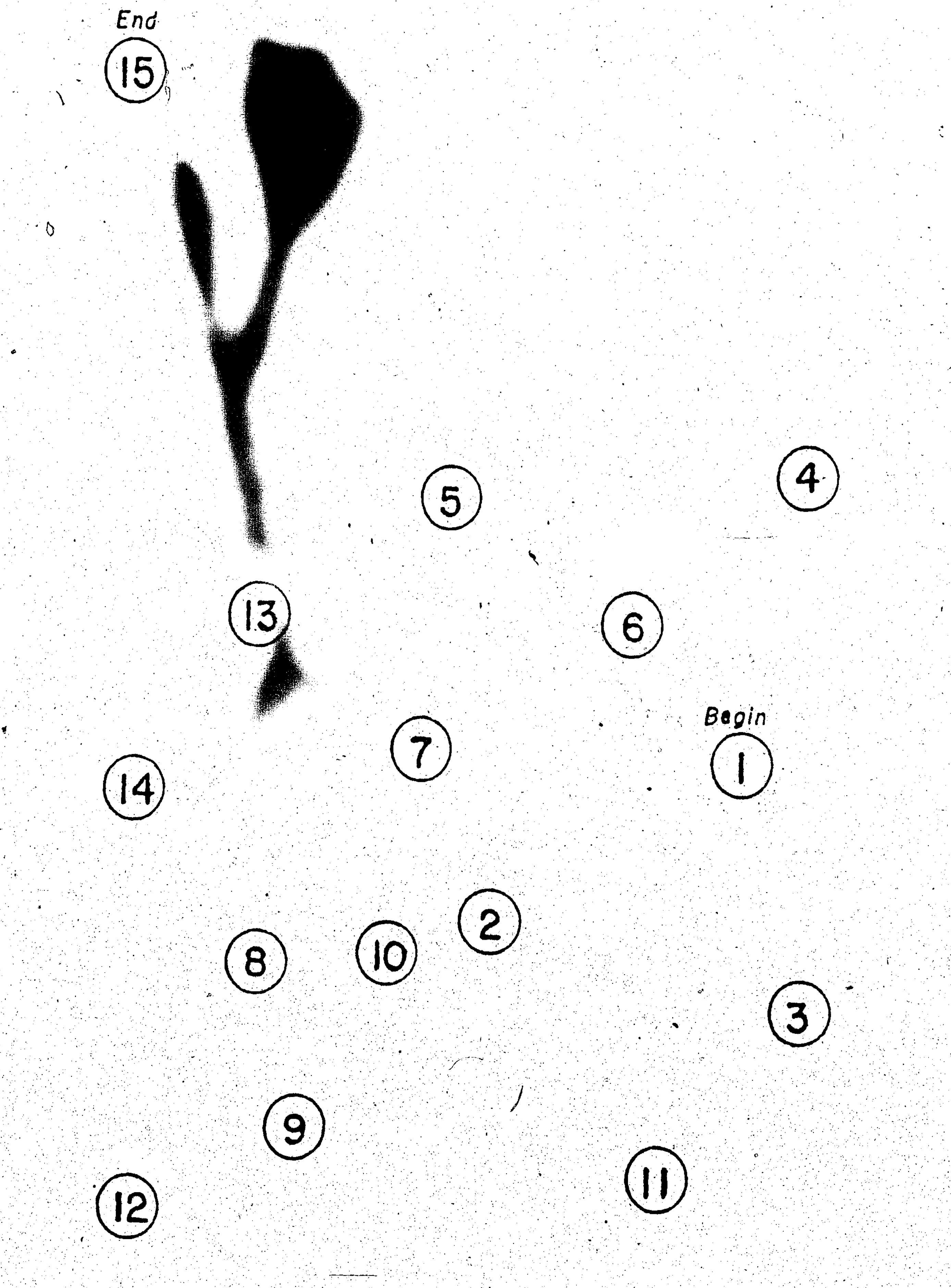
"This part is similar to the other except there are both numbers and letters. In this test, your task is to draw a line from 1 to A, from A to 2, from 2 to B, from B to 3 and so on in this way until you get to the end. Work as quickly as you can. If you make an error, cross it out and go on quickly."

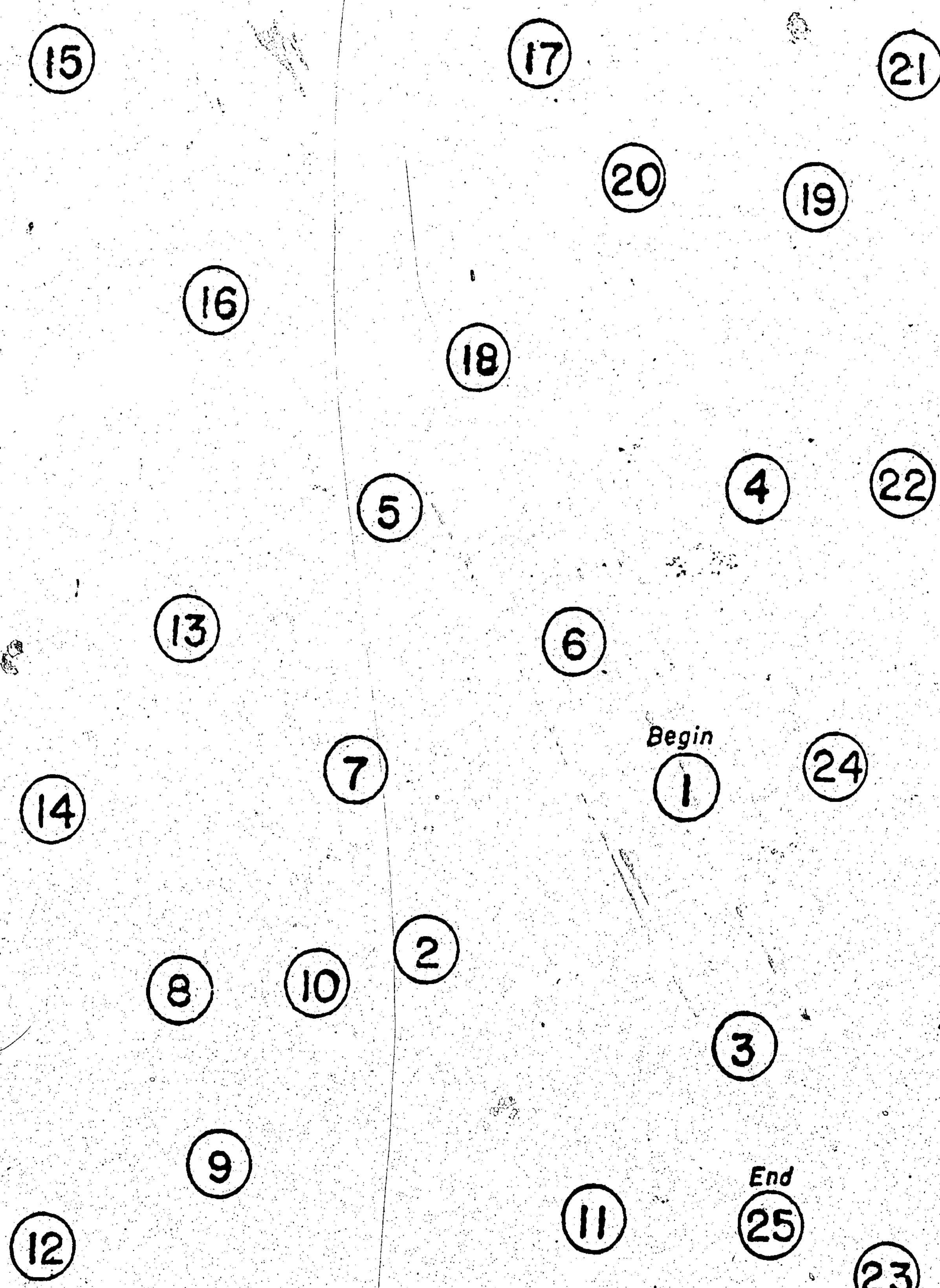
INTERMEDIATE FORM
TRAIL MAKING

Part A

SAMPLE



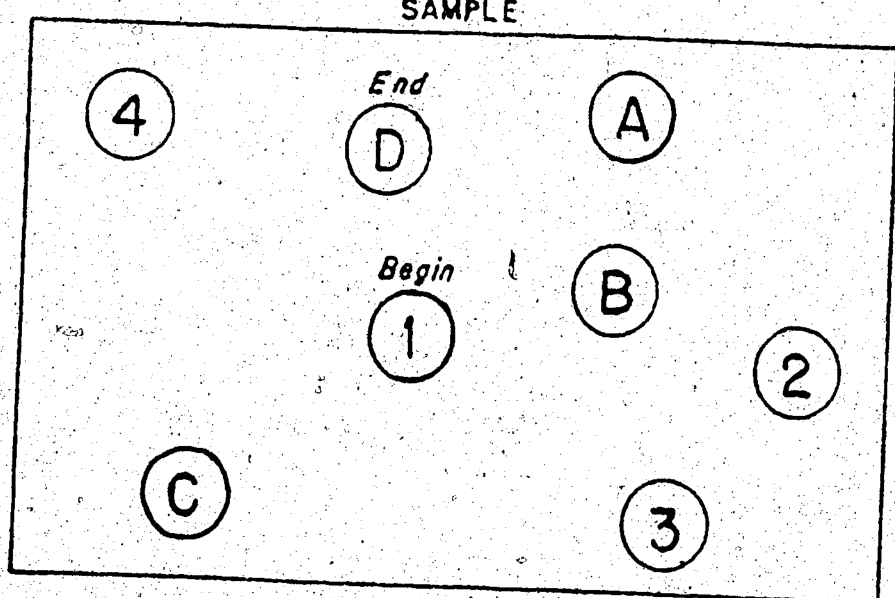

End
15
4
5
13
6
Begin
1
7
14
2
8
10
3
9
11
12

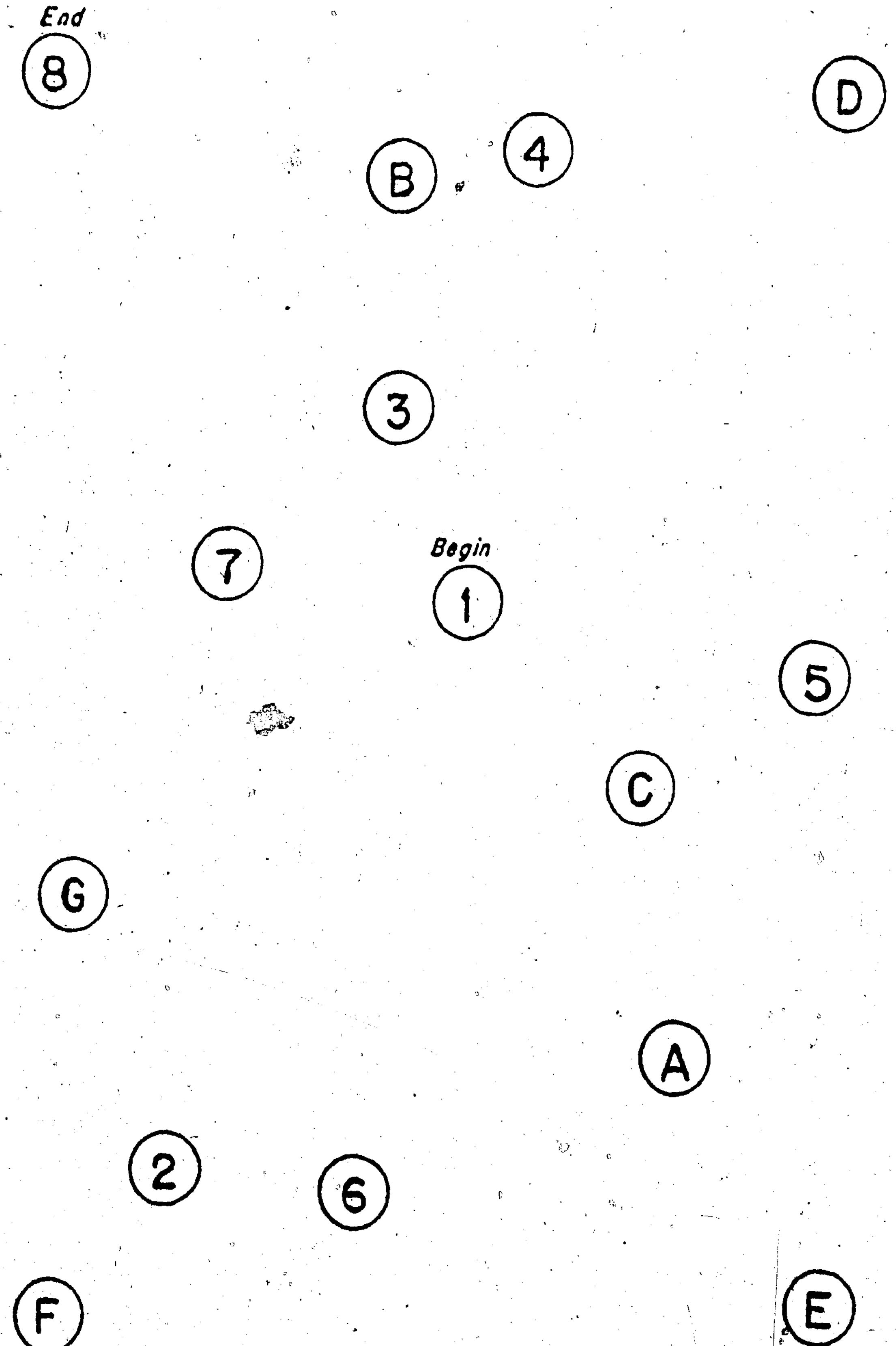

15
17
21
20
19
16
18
5
4
22
13
6
Begin
1
7
24
14
2
8
10
3
9
End
25
11
12
23

TRAIL MAKING

Part B

SAMPLE




End
8
D
4
B
3
7
Begin
1
5
C
G
A
2
6
F
E

APPENDIX D

Directions for the Experimental Trial-Making Task

PART A: Experimental

"This part is similar to the others we have done except that there are only numbers in this part of the task. In this test your task is to draw lines between the numbers on the page in the correct order - from 1 to 2, from 2 to 3, from 3 to 4 and so on, until the end is reached. Do it as quickly as possible."

PART B: Experimental

"Here we have another test in which you must join the numbers consecutively, by drawing lines between them in the correct order, that is as if you are counting. Do it as quickly as possible."

TRAIL MAKING A

2. 1.

4. 3.

6. 5.

8. 7.

10. 9.

12. 11.

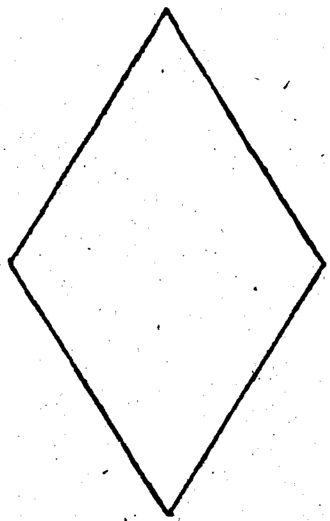
14. 13.

TRAIL MAKING B

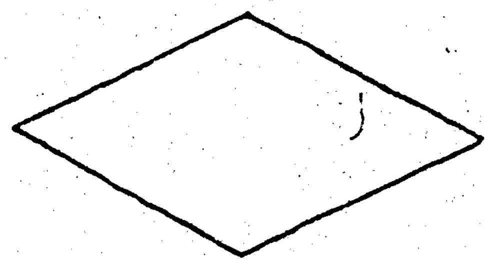
2	1
3	4
6	5
7	8
10	9
11	12
14	13

Figure Copying

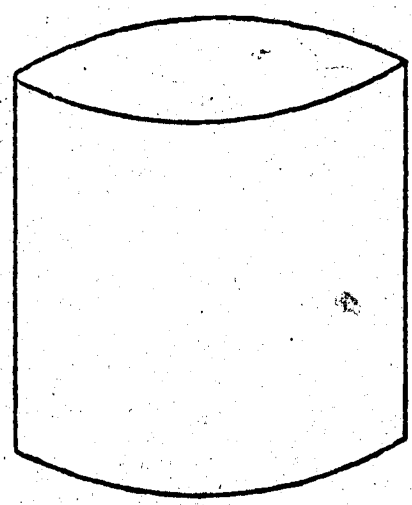
1.



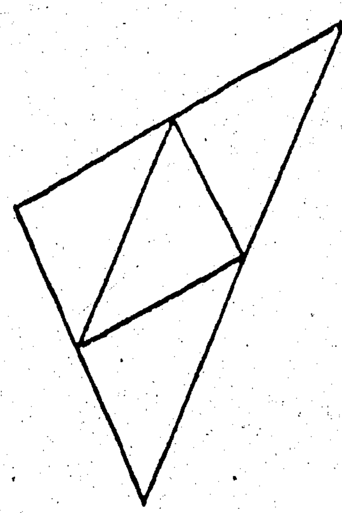
2.



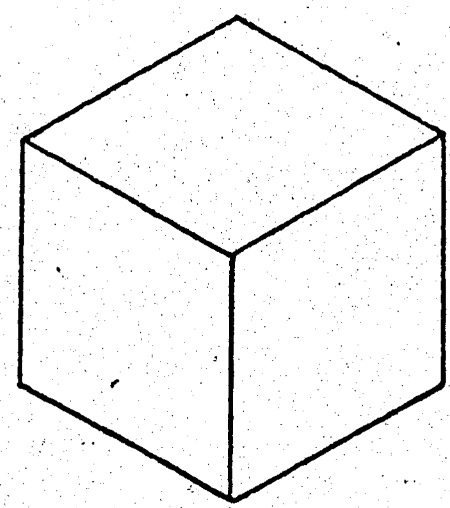
3.



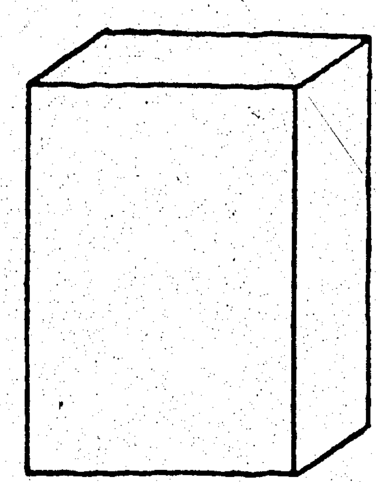
4.



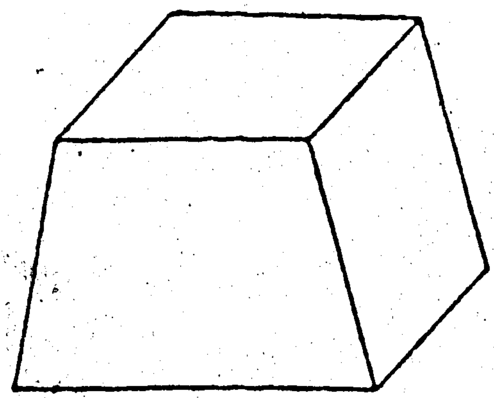
5.



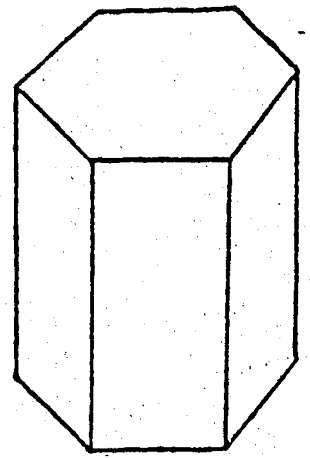
6.



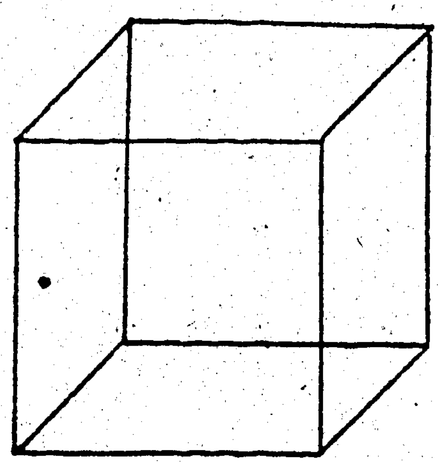
7.



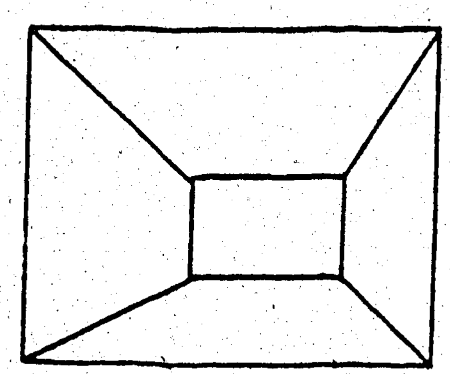
8.



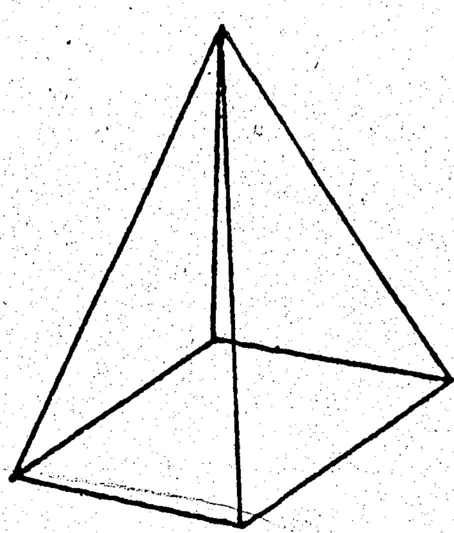
9.



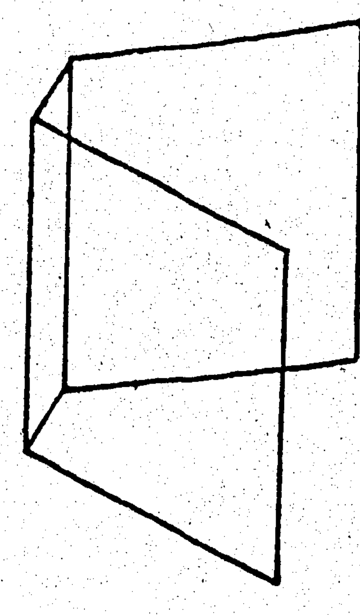
10.



11.



12.



Guidelines for administering and scoring the Figure Copying Test

The subject is required to make an exact, free-hand copy of twelve shapes: a vertical diamond; a horizontal diamond; a cylinder; tilted triangles; a cuboid; an enclosed box; a trapezoid; an octahedron; a necker cube; a tapered box; a pyramid; and a stylized open book. Drawings are scored according to accuracy of shape rather than absolute size. The following principles apply:

For all drawings

1. The drawings must generally maintain the proper perspective.
2. Drawings where applicable should be symmetrical.
3. Angles should not be rounded.
4. Figures should not be rotated.
5. Angles should be equal, when applicable.
6. Slight bowing or irregularity of lines is permitted.
7. Lines should meet approximately, but small gaps or extensions are acceptable.
8. When two attempts are made, the worst is scored.

Scoring principles for individual figures

Scoring of each figure involves some limited flexibility. In general, some principles are considered more important than others and are more stringently enforced. In the following table of standards, criteria are given in order of importance. Where the same numbers are given for two criteria, they are considered equally important.

1. Vertical Diamond

   1. No 'kite' shapes

   1. Horizontal opposing corners

   2. Four good corners

   3. Only slight 'dog-ears' allowed

   4. Both acute angles must be 60° or less

2. Horizontal Diamond

   1. No obvious 'kites'

   1. Opposing corners

   2. Four good corners

   2. Horizontal axis between 170° and 190°

   3. Both acute angles 60° or less

3. Cylinder

   1. Diameters should be approximately equal to the height

   2. Diameters of the base and top should be approximately equal

   2. The base and the top lines should be curved.

4. Tilted Triangles

   1. Two triangles

   2. Right outer side sloped 100° or more

   3. Two corners of inner triangle clearly touch near medians of outer triangle, and the third must be close.

   3. Left outer angle approximately 90°

5. Cuboid

   1. Proper perspective must be preserved as in the specimen
   2. There should be three approximately equal diamonds
   3. All lines should be approximately equal (ie. lengths, widths, and heights)

6. Enclosed Box

   1. Proper perspective must be maintained as in the specimen
   1. Figure must be almost half as high as it is wide
   2. Acute angles of parallelogram should be between 30^{0} and 45^{0}

7. Trapezoid

   1. Proper perspective should be preserved as in the specimen
   2. Parallelograms should have angles of approximately 45^{0}

8. Octahedron

   1. Hexagon should have approximately equal sides
   2. Vertical rectangle should be bounded by two, near equal parallelograms
   3. Left and right extreme angles of the hexagon should be near 90^{0}

9. Necker Cube

   1. Correct number of parts
   1. Correct orientation
   1. No evidence of confusion

10. Tapered Box

   1. No confusion or distortion

2. Inner form clearly shifted to the right and down

3. Outer form a parallelogram

3. Inner form a horizontal rectangle

11. Pyramid

1. Figure is balanced around the vertical

1. No confusion or distortion

2. Base of figure is a diamond

2. All triangles are near isosles

12. Stylized Open Book

1. Two, mirror-image parallelograms with the acute angles near 75^{0}

1. No confusion or distortion

2. Thin parallelogram should have acute angles between 30^{0} and 45^{0}

APPENDIX F

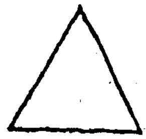
DIGIT SPAN Name_______________ # _________

5-8-2	3
6-9-4	3
6-4-3-9	4
7-2-8-6	4
4-2-7-3-1	5
7-5-8-3-6	5
6-1-9-4-7-3	6
3-9-2-4-8-7	6
5-9-1-7-4-2-8	7
4-1-7-9-3-8-6	7
5-8-1-9-2-6-4-7	8
3-8-2-9-5-1-7-4	8
2-7-5-8-6-2-5-8-4	9
7-1-3-9-4-2-5-6-8	9

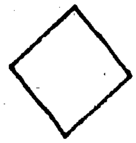
APPENDIX G

Memory-for-Design Test (MFD)

1

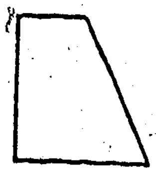


2



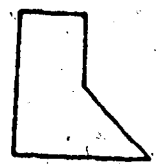
3

4

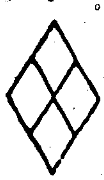


5

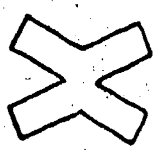
6



7

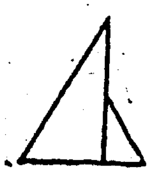


8

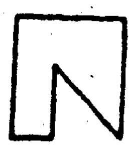


9

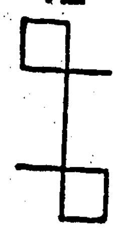
10



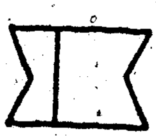
11



12

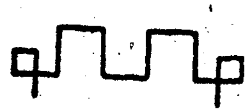


13



14

15



APPENDIX H

INSTRUCTIONS

1. Read Statements
2. Solve Problem
3. Is the Conclusion True or False
4. Circle the Correct Answer

For example: Tina is smaller than Sally

Sally is smaller than Ann

Conclusion: Tina is smaller than Ann (True) or False

SHEET I

Time: ____________________

1. Mary is taller than Sue.
   Sue is taller than Joan.

   Conclusion: Mary is taller than Joan. True or False

2. Ann is shorter than Jane.
   Jane is shorter than Alice.

   Conclusion: Alice is shorter than Ann. True or False

3. Alice is older than Sally.
   Sally is older than Ann.

   Conclusion: Alice is older than Ann. True or False

4. Joan is younger than Susan.
   Susan is younger than Donna.

   Conclusion: Joan is younger than Donna. True or False

5. Betty is taller than Karen.
   Karen is taller than Carla.

   Conclusion: Carla is taller than Betty. True or False

6. Sharon is younger than Cheryl.
   Cheryl is younger than Rita.

   Conclusion: Rita is younger than Sharon. True or False

7. Peggy is older than Ruth.
   Ruth is older than Leanne.

   Conclusion: Peggy is older than Leanne. True or False

8. Marie is shorter than Angela.
   Angela is shorter than Gina.

   Conclusion: Gina is shorter than Marie. True or False

SHEET 2

Time: ______________

1. Susan is taller than Ann.
   Jane is taller than Susan.

   Conclusion: Ann is taller than Jane. True or False

2. Frances is shorter than Joan.
   Susan is shorter than Frances.

   Conclusion: Joan is shorter than Susan. True or False

3. Sharon is younger than Mary.
   Leanne is younger than Sharon.

   Conclusion: Leanne is younger than Mary. True or False

4. Norma is older than Alice.
   Karen is older than Norma.

   Conclusion: Karen is older than Alice. True or False

5. Rita is shorter than Janice.
   Sally is shorter than Rita.

   Conclusion: Janice is shorter than Sally. True or False

6. Lily is taller than Ruth.
   Cheryl is taller than Lily.

   Conclusion: Ruth is taller than Cheryl. True or False

7. Allison is younger than Pam.
   Diane is younger than Allison.

   Conclusion: Diane is younger than Pam. True or False

8. Jane is older than Sally.
   Sybil is older than Jane.

   Conclusion: Sybil is older than Sally. True or False

SHEET 3

Time: ______________

1. Ann is taller than Alice.
   Susan is shorter than Alice.

   Conclusion: Susan is taller than Ann. True or False

2. Betty is shorter than Gina.
   Sharon is taller than Gina.

   Conclusion: Betty is shorter than Sharon. True or False

3. Marie is younger than Carla.
   Betty is older than Carla.

   Conclusion: Marie is younger than Betty. True or False

4. Cheryl is older than Betty.
   Susan is younger than Betty.

   Conclusion: Cheryl is older than Susan. True or False

5. Norma is taller than Sharon.
   Ruth is shorter than Sharon.

   Conclusion: Ruth is taller than Norma. True or False

6. Ellen is shorter than Susan.
   Alice is taller than Susan.

   Conclusion: Ellen is shorter than Alice. True or False

7. Lily is younger than Susan.
   Pam is older than Susan.

   Conclusion: Pam is younger than Lily. True or False

8. Ann is older than Sarah.
   Becky is younger than Sarah.

   Conclusion: Becky is older than Ann. True or False

SHEET 4 Time: ______________

1. Peggy is taller than Susan.
Peggy is shorter than Becky.

Conclusion: Susan is taller than Becky. True or False

2. Gina is shorter than Ruth.
Gina is taller than Leanne.

Conclusion: Leanne is shorter than Ruth. True or False

3. Carla is older than Diane.
Carla is younger than Rita.

Conclusion: Rita is older than Diane. True or False

4. Karen is younger than Susan.
Karen is older than Anna.

Conclusion: Anna is younger than Susan. True or False

5. Ann is taller than Susan.
Ann is shorter than Sally.

Conclusion: Susan is taller than Sally. True or False

6. Sally is shorter than Pam.
Sally is taller than Pat.

Conclusion: Pam is shorter than Pat. True or False

7. Susan is older than Sarah.
Susan is younger than Joan.

Conclusion: Sarah is older than Joan. True or False

8. Margaret is younger than Pam.
Margaret is older than Sally.

Conclusion: Pam is younger than Sally. True or False

APPENDIX I

Directions for the Mastermind Task

Testing Procedure

The directions to each subject were played on a cassette tape recorder, and were as follows:

"This is a game which involves problem solving. There are six colour coded pegs in this game, they are: blue, brown, yellow, red, green and orange. In each game I will choose four different colours out of the six. I will place these coloured pegs into holes which are shielded from your vision. You will not be able to see them.

Your task is to try to duplicate the exact colours I have chosen, and their exact position, by placing them into the board. You may choose any four of the six coloured pegs, in each row. One important thing you must remember is that the colours I have chosen all differ from one another, so no two colours are the same.

After you have placed the four coloured pegs into the board, I will tell you whether the pegs you have chosen are correct in colour and whether the pegs were in the right position. If your peg matches the one I have chosen in colour, but is not in the correct position, I will put a white peg into the key peg holes adjacent to your row. If your coloured peg matches the one I have chosen in it's colour and is also in the correct position, I will put a black peg into the key peg hole. If you choose a colour which does not match the colour I have chosen, the key peg holes adjacent to your row will be left empty. This will tell you that the colours you have chosen are not correct.

Let me review the instructions for you. Your job in this game is to duplicate the coloured coded pegs and their positions which I have chosen. When you duplicate it, I will place four black key pegs adjacent to your row of pegs. This will indicate to you, that you have matched the exact colours and positions of the code I have chosen.

Are there any questions before we begin? Also if you have any questions during the game please don't hesitate to ask me.

Experimenter Colour Codes

Trial 1	- brown, yellow, red, green
Trial 2	- green, orange, red, blue
Trial 3	- orange, red, yellow, green

APPENDIX J

Table 26

Study One: Factor Correlations after Oblique Rotation of Marker Tests (n=50)

Variable	Simultaneous	Successive
Simultaneous	1.0000	.14071
Successive	.14701	1.0000

Table 27

Study Two: Means and Standard Deviations of Visual Search Experiment for Top and Bottom Quartile Groups (in Secs.) (n=28)

VARIABLE	MEAN	STANDARD DEVIATION
Group		
Top - Trial 1	3.30	1.33
Trial 2	1.84	.47
Trial 3	1.62	.38
Trial 4	1.57	.50
Bottom- Trial 1	8.46	3.20
Trial 2	5.18	1.52
Trial 3	6.07	2.88
Trial 4	4.06	2.06