THE RELATION OF VISUAL RECOGNITION THRESHOLD DURING SEQUENTIAL PART PRESENTATION TO HIGHER COGNITIVE VARIABLES: A STUDY OF SPATIAL AND TEMPORAL ORDER

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ABSTRACT

A technique is described wherein parts of a visual form can be sequentially presented at an increasing rate until the 'elements' integrate into a percept. Previous use of this technique (Sequential Part Presentation or SPP) had persistently resulted in significant correlations between the integration threshold for words and other visual forms, and tests of higher cognitive ability, namely: Henmon Nelson IQ, Embedded Figures Test, Differential Aptitude Tests for Spatial Ability and Abstract Reasoning.

In the present experiment two types of stimuli were chosen and administered, on the basis of two theories advanced to explain the above covariation. A consequence of one theory was to expect similar covariation using a form which was meaningless, having no verbal and little spatial organization, and which would give a 'pure' measure of _S_'s ability to reduce apparent motion. A deduction from the alternate theory was to expect a) insignificant covariation using the nonsense form, but b) significant correlations using a meaningful form, i.e., words. The experiment was also designed to test the influence on integration thresholds and correlations of an orderly sequential presentation of parts vs a random sequence.

The results favoured the latter theory. Correlation coefficients for meaningful forms proved to be larger and more consistent with the several cognitive tests, than were the correlations for nonsense forms. A random order of presentation generally resulted in higher integration

thresholds and larger correlations for both nonsense and meaningful forms, than did an orderly sequence.

Some idiosyncratic results were noted. A comparison was made of the results from the only two experiments to date, to use the SPP technique. Finally, several possible areas for additional research were suggested.

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CHAPTER I

INTRODUCTION

The purpose of this experiment is to investigate in greater detail, the nature of the demonstrated relationship between a perceptual recognition task and tests of higher cognitive ability. Recognition threshold for different visual forms had been found to covary with measures of higher cognitive processes (den Heyer, 1967). One explanation for the covariation involves the consideration of a temporal integration mechanism, which becomes a factor as a result of the special technique of stimulus presentation utilized. This technique involves the rapid, sequential presentation of parts of a visual form. By increasing the rate of sequential presentation, apparent motion between the parts is eventually produced; as higher rates of presentation are introduced, apparent motion (AM) finally ceases and recognition occurs. Another explanation suggests that AM is affected by the meaning of the visual forms, and that the differential ability of Ss to reduce AM via the form's meaning, accounts for the covariation with cognitive tests. The specific goal of this experiment is to discover the role that meaning plays in determining the correlation coefficients with those tests. The present design is also based on the assumption that for meaningful forms, the more difficult or random the order of presentation for a form's parts, the greater will be the correlation with criterion variables - the cognitive tests.

To best understand this rationale, the design and results of the experiment by den Heyer will be introduced. Both his experiment and the present study evolved from two earlier works by Springbett, Dark, and Clarke (1957), and Springbett (1957), which were intended to be preliminary investigations on the creative process. Therefore, consideration of those two works will first be undertaken.

The Lines Test

In the initial study (Springbett et al., 1957) the Lines Test was introduced as a possible approach to the measurement of creative thinking. Three types of figures consisting of nine lines could be represented on 4 x 4 grids. They were classified as meaningful (M), gestalt (G), or nonsense (N) figures, examples of which are given in Figure 1. A figure was presented to S one line at a time every two seconds, on nine separate 4 x 4 grids, such that it was impossible to view the whole figure simultaneously. The task was presented as one of rote memory, to reproduce as many of the lines as possible in their proper spatial position on a separate, blank 4 x 4 grid.

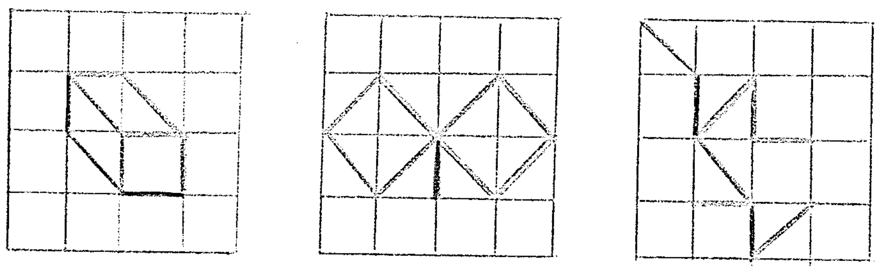
The second study (Springbett, 1957) used basically the same procedure, but replaced meaningful figures with words, and replaced gestalt figures with mirror images of words. Nonsense figures formed the third type of figure. Three examples are shown in Figure 2.

The rationale for such a procedure may be given as follows (Springbett, 1957; p. 233):

> In brief, the presence of a hidden organization is assumed to arouse processes of which we are not conscious. It is assumed that the creative thinker is sensitive to such processes. Creative thinking

FIGURE I

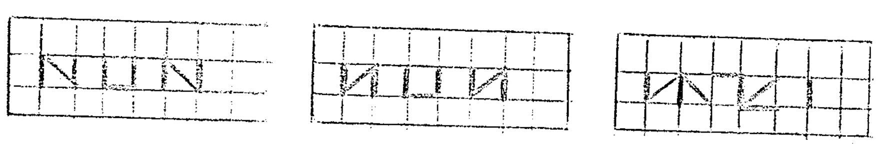
THREE TYPES OF LINES TEST FIGURES
(from Springbett et al, I957)



Meaningful Gestalt Nonsense

FIGURE 2

THE LINES TEST WITH VERBAL ORGANIZATION
(from Springbett, I957)



Verbal Distorted Nonsense

> is viewed as differing from problem solving only in degree, as the present test differs only in degree from conventional tests of reasoning and intelligence. Hence it is expected that scores on the meaningful figures will show substantial correlation with tests of verbal intelligence, the distorted words less correlation, and nonsense figures least.

The two experiments appeared to support such reasoning.

The results from the first experiment demonstrated that M figures are significantly easier to reproduce than G figures, while G figures are, in turn, significantly easier to reproduce than N. And since few of the M or G figures were perfectly recreated, i.e., consciously recognized, it could be argued that the scores were indeed influenced by unconscious factors related to partially aroused cognitive structures.

Furthermore, in both experiments M and especially verbal figures correlate noticeably better with tests of verbal intelligence than do the remaining types of figures. The second experiment was better designed to test the influence of a partially aroused verbal organization, as it contained definite words rather than meaningful forms (M) to which words could be attached. In addition, both experiments generally resulted in substantial correlation of all types of figures with tests of spatial ability, and in the first study there were substantial correlations of M and G figures with a test of abstract reasoning.

Such patterns of correlations with cognitive tests (only some of which are reported here) added support to the view that the Lines Test procedure "must yield some measure of the interaction of conscious and unconscious processes," (Ibid., p. 231) and in this way would offer an approach to the study of creative thinking.

Perceptual Integration

With these intial encouraging results, the next variable investigated was the rate of presentation of a form's parts. The earlier Lines Test had presented, on stenciled grids, one line of a figure every two seconds. Using a different technique called sequential part presentation (SPP), and starting at the rate of eight lines per second (l/s), den Heyer (1967) was able to increase the rate of presentation until the form appeared to integrate into a recognizable whole. The task becomes altered from one of rote memory and conceptual integration in the Lines Test, to one of perceptual integration. It was the primary concern of this study to discover whether the results of the previous experiments could be replicated using data from a perceptual recognition task.

Briefly, there were three types of visual forms: meaningful (M), verbal (V), and nonsense (N). These forms were constructed from 9 neon lamps whose rate and sequence of firing could be carefully controlled (see Apparatus and Appendix A). Starting at the rate of 8 l/s ('l' stands equally for light or line), which means that an entire form of 9 lights is presented in roughly one second, S was confronted with the unknown form and was asked to replicate what he saw. The rate of presentation was increased in steps of 4 l/s after every failure at correct reproduction, and this procedure continued until success occurred.

Therefore, one test variables was the rate in l/s at which successful reproduction or perceptual integration occurred (SPP condition). The same visual forms were presented tachistoscopically, and the recognition threshold for this condition (T) became the second test variable. Both scores were then correlated with the results from the following cognitive tests: Henmon Nelson Tests of Mental Ability (HN), Differential Aptitude Test of Space Relations (SR), Embedded Figures Test (EFT), Remote Associations Test (RAT).

In the investigator's opinion, with one major exception, the pattern of results in the SPP condition did indeed conform to the results obtained in the earlier studies utilizing the Lines Test.

First, in both SPP and T conditions significant differences in recognition thresholds were found between the M, V, and N figures, N having the highest threshold. Second, the main findings again refer to the fact that significant correlations are to be found between SPP scores and cognitive tests. The results are summarized in Table I, using the combined data for male and female subjects.

The major exception alluded to was the superior pattern of significant correlations for nonsense figures in the SPP condition, especially with DAT-SR. The combination of this result with the fact that T scope scores had a different and less significant overall pattern of correlation, suggested the following interpretations of results.

A basic assumption is that there exists some underlying neural structure responsible for cognition. The concept is similar to Hebb's phase sequence or T assembly. It is the arousal of these underlying neural structures which accounts for the superior performance of familiar, in contrast to nonsense, figures, in the Lines Test and SPP.

TABLE I

CORRELATION COEFFICIENTS BETWEEN PERCEPTUAL AND COGNITIVE VARIABLES (From den Heyer, 1967)

	Perceptual Variables					
Cognitive Variables	Meaningful SPP	Meaningful T	Verbal SPP	Verbal T	Nonsense SPP	Nonsense T
Quantitative IQ	.079	-.093	-.106	-.007	-.220	-.021
Verbal IQ	.053	.015	-.313*	.067	-.139	-.042
HN Total IQ	.075	-.048	-.267*	.007	-.203	-.046
EFT	.260*	.044	.252*	-.047	.318*	-.125
DAT-SR	-.339*	-.137	-.382*	-.279	-.625*	-.151
RAT	-.044	-.104	-.055	-.022	-.072	-.240

*$p < .05$, $df = 55$, $t > 1.680$.

The covariation between SPP and cognitive tests was at first thought to be explained by the presence of meaningful organizations relevant to both. Thus, verbal figures maintained the highest correlation of all forms with the Henmon Nelson Test of Verbal Ability; and verbal and meaningful figures, containing familiar spatial structures, correlate well with EFT and DAT-SR, tests utilizing similar organizations.

To explain how N figures, which supposedly have no underlying neural organization, correlate just as well and even better with EFT and DAT-SR, den Heyer proposed the existance of a learning factor. Because there is no underlying structure aiding perception of N figures, a learning process must occur for a phase sequence, or some analogous structure, to build up during repeated trials before perceptual integration occurs. Furthermore, since T scope presentation also fulfills these two conditions, that is, it allows for a) the arousal of meaningful organizations, and b) for perceptual learning in the case of N figures, and since there is not the same pattern of significant correlation with the cognitive tests as found with SPP, it was further argued that the sequential presentation of parts, with the introduction of temporal organization into the task, is an essential requirement before a perceptual task simulates higher cognitive processes. T scope presentation does not require the temporal integration of parts, and consequently does not correlate as well with the cognitive tests.

The relationship between SPP and cognitive tests was thus attributed to three factors: a) common organizational factors inherent in both forms and cognitive tests, b) perceptual learning in the case of nonsense figures, c) the requirement of temporal as well as spatial integration.

Temporal Integration

An expanding amount of experimental evidence having to do with the 'timing' of information perhaps offers some background to the present results concerning sequential part presentation.

Stroud (1957, 1967) and Efron (1967) offer evidence which characterizes the brain as taking information in discrete moments, or what Efron prefers to call 'processing periods', of from 50 to 70 milliseconds in duration (Efron's figures). Within this processing period both the time order and even the quality of events is lost to the perceiver. For example, Lichtenstein (1961) demonstrated that apparent simultaneity between four sequentially flashing lights in a diamond pattern, occurs at a frequency of 125 msecs/4 lights, regardless of light sequencing. Thus 125 msecs was the threshold at which time differentiation for perceiving order ceased. Smith (1967) discussed the theory of 'quantized' perceptions in relation to theories of the psychological refractory period. In the same area, Berstein, Blake, and Hughes (1968) produced evidence that reaction times are greatest following an interstimulus interval of no longer than 75 msecs, a figure somewhat closer to Efron's estimation. As for the quality of events occurring within these ranges, Efron cites preliminary studies where a 20 msec flash of red followed by 20 msecs of green, results in the perception of yellow; a red-green-red combination of 30-30-30 msecs is seen as yellow followed by red; a red-green-red-green combination of 30-30-30-30 msecs becomes yellow again. Thus, events occurring within the 60 msec range appear to be integrated.

The theory most often used in attempting to explain such regularities has been the cybernetic model of Winer (1948) and McCulloch and Pitts (1947), which stresses the importance of a scanning process, presumably the alpha rhythm, for perception. Murphee (1954) has offered some evidence that the alpha rhythm plays an integral role in form perception, apparent motion, and figure-ground reversals. Studies by Canter and Fleming (1966), and Donchin, Wicke, and Lindsy (1963) also cite correlations between cortical potentials and subject's reports of light flashes. There is some question, however, whether the 'processing period' is related to a cyclical mechanism, such as the alpha rhythm, or whether it is related to some other type of mechanism (Efron, 1967; p. 727).

Within the context of the present technique of sequential part presentation the implication is that perhaps, during stimulus presentaton, the imposition of temporal interruptions interacts with this processing period. If such periods are essential to mental functioning it may be that individual differences (in the alpha rhythm for example) account for generalized abilities across various cognitive tests, and in this way performance during SPP is related to performance on those cognitive tests. Hence the ability to retain, or temporally integrate, a sequence of parts during SPP may well be related to the ability, in tests of spatial reasoning, to maintain an abstract visual structure, and in EFT, to maintain a correct image of the original figure.

The Role of Apparent Motion

During SPP the temporal interval and spatial separation between lights become such that apparent motion (AM) always occurs prior to perceptual recognition. It is when AM ceases that recognition takes place. The proximity of these two events, AM cessation and subsequent recognition, suggests that any factor which influences AM would similarly affect the recognition threshold.

One possibility is that individual differences in the 'processing period' spoken of above, influence the perception of AM. For example, it is known that sufficient differences do exist in perceiving the onset and cessation of AM to allow for correlations with neuroticism (Hamilton, 1960) , and age and IQ (Pollock, 1965; Hamilton, 1960). Attention is again drawn to the study by Murphee (1954) which produced evidence in favor of a relation between AM and the alpha rhythm, which is theoretically related to a 'processing period'.

There is also indication, however, that meaning reduces AM (Toch & Ittellson, 1956), and that AM is more persistent when the directional information is ambiguous or random (Brown, 1956; Jeeves & Bruner, 1956; Jeeves, 1964). Therefore, another explanation suggests that during SPP, AM is affected by the meaning of the visual form, and that the differential ability of Ss to reduce AM via the form's meaning accounts for the covariation with the cognitive tests.

Support for this hypothesis can be drawn from the results of the Lines Test and the one previous experiment on perceptual integration, where success on verbal and meaningful forms is significantly related to success on a test of verbal ability. Similarly, spatial, but nonverbal structures, which do not correlate with verbal tests, do correlate significantly with EFT and a test of spatial ability. Analogous to the reasoning for the Lines Test, the presence of certain underlying neural organizations, as measured by tests of verbal and spatial ability, help to reduce, in the case of SPP, AM between lights. The result is a reduction in the integration threshold for perceptual recognition.

In this case, one would expect that a form which was not related to verbal organization, and which was simple in construction, that such a form, presented sequentially, should produce insubstantial correlation with tests measuring those capacities. It is with this idea in mind that the present study will present to Ss, two types of visual forms consisting of words (W forms), or a simple horizontal array of vertical lines (HA forms). The words are expected to correlate with a test measuring verbal ability, and with a test of spatial ability, basically replicating the experiment of den Heyer. The horizontal array, however, is not expected to correlate with those same tests to any extent.

Difficulty of Task

The rationale of the Lines Test had argued for the continuity of creative thinking with other areas of problem solving. Creative thinking was defined as existing in those situations where the solution to a problem was not explicitly present among the elements of the task; and the creative thinker was defined as an individual sensitive to hidden or unconscious processes which 'supply' that solution or principle completing the task.

In the case of the Lines Test (Springbett, Dark, & Clake, 1957) M and G figures had significant correlations of .57 and .58 respectively, with a test of abstract reasoning (D.A.T. AR). N figures did not correlate significantly. The abstract reasoning test was described as presenting a relatively simple problem - 'simple' because the matrices, through which the hidden principle giving solution to the task is presented, are given in an orderly sequence. Thus, the principle is 'readily' discovered. The Lines Test was described as being similar to abstract reasoning, but different, in that the hidden principle could not be easily discovered as with abstract reasoning. The two tests correlate because they involve the same type of task.

> It is of interest to note also that the highest correlations are obtained with the D.A.T. Abstract Reasoning Test. Matrices tests are the closest in principle to the Lines Test since they contain a 'hidden principle', but one which, because of the orderly sequence of the matrices, is relatively easy to discover. (Springbett, Dark, & Clake, 1957; p. 18).

If the simulation of higher cognitive processes, by the Lines Test and SPP, rests upon their ability to conceal effectively the basic organization of the visual forms presented, it is of potential interest to inquire into possible factors which control difficulty of the task. For example, D.A.T. AR is described as being easy, because the matrices are presented in orderly sequence.

In the only test to date utilizing SPP, den Heyer had presented the elements of the figures in a random order (R). A random order of presentation had also been used for the Lines Test. If the elements, in both SPP and Lines Test, had been presented in an orderly sequence, it is possible that the tasks would become too easy, that all Ss would perceive the figure at equally low thresholds, and that any correlations with cognitive tests, especially abstract reasoning, would become insignificant as a result of the common threshold.

In relation to the different HA and W figures in this experiment, it is argued that for both forms, an orderly presentation of elements consisting of a left-to-right sequencing of lights, will result in lower integration thresholds, and possibly insignificant covariation with the cognitive tests. However, during a random order of presentation, it is expected, for the words only, that integration thresholds will increase, and that significant covariation with the cognitive tests will again be found.

The same is not expected to occur with the HA form for two reasons. First, perception of words takes place in a sequential fashion, from left-to-right. A random order of presentation would appear to be more temporally disrupting for a word, than for a simple, uniform structure such as the horizontal array. The orderly method of presentation is thus called natural (N) presentation, in relation to the naturalness of reading words left-to-right. The integration of temporally disparate elements should not be as acute for the HA form as for the words. Second, explanation of the covariation with all cognitive tests to be utilized, Verbal IQ, EFT, D.A.T. Spatial Ability and D.A.T. Abstract Reasoning, involves the consideration of verbal and spatial organizations of which the HA is thought to be devoid. Thus, for both N and R orders of presentation, HA is not expected to covary with any of the cognitive tests.

But if, for example, R resulted in significant and higher correlations for W and HA forms together, and not for W forms alone, this would suggest a) that the role of relevant underlying organizations in the reduction of AM has been overemphasized, and b) that the covariation with cognitive tests may be due instead, to individual differences in some mechanism, such as a processing period or alpha rhythm, which influences the scores on a variety of tests, and in the case of SPP influencing perception of apparent notion. If this occurs, superior correlation during R, in contrast to N, for both W and HA forms, could be explained by the fact that AM is more persistent during random presentation (Jeeves & Bruner, 1956); thus condition R would be more able to differentiate those with the appropriate ability to reduce AM than would condition N.

Using the above methods, by manipulating the temporal and spatial order during SPP it is hoped that some insight can be gained concerning the common factors causing covariation with the cognitive tests.

CHAPTER II

METHOD

An important part of this experiment depends upon choosing a figure which has little or no verbal and spatial organization. If the assumption is correct, that AM is reduced through the existence of underlying neural structures independent measures of which are afforded by tests of verbal and spatial ability, and possibly EFT, then a figure devoid of such features should not covary with any of those tests. Den Heyer used nonsense figures in his experiment, but they proved to yield higher correlations than both verbal and meaningful figures with EFT and a test of spatial ability. Unlike these nonsense figures, however, which were quite spread out requiring some organization, the horizontal array chosen for this study presented a relatively easy task. Ss did not have to determine the spatial position of each light, since their arrangement is fairly obvious, but instead, were told to concentrate on giving the correct number of lights in the array, and to indicate roughly the spaces between the lights. The latter task is also easy since all spaces separating the lights are equal except for one identifying double-spaced gap between two lights (see Figure 4). It seems that both these tasks could be easily accomplished after the complicating influence of AM had stopped. Ideally, the correlations obtained with this figure should give a good indication of the relative importance of 'pure' AM reduction, that is, the ability to reduce AM without the confounding factors of verbal and spatial organization

Apparatus

Additional information concerning the apparatus may be found in Appendix A. In accordance with the purpose of the original Lines Test, the essential feature of this apparatus is the sequential presentation of parts of a visual form, pattern or word. The rate of sequential part presentation (SPP) must be easily manipulated and be of such a frequency that the task is a perceptual one rather than the rote memory aspect of the Lines Test. With these stipulations in mind, Mr. Bell (technician, Department of Psychology, University of Manitoba) devised and constructed the perceptual integration apparatus used by den Heyer and the present study.

There are three basic components. Switching circuits located in box A, Figure 3a, determine the sequence in which 9 lights, plugged into the outlets within the box, will fire. Regardless of sequence, all 9 lights must come on before the first in the series fires again. The length of time any repeating sequence continues is controlled by the Hunter Interval Timer, box C. For this study a 10 second duration was used. The 'on' period for each single light is controlled through box B. It's construction was such that the time interval separating the firing of consecutive lights was equal to the 'on' period of each light. The on/off ratio is thus I:I. Within this format, the frequency of firing can be varied from 6 l/s to 115 l/s.

The 9 lights which were used in creating the stimulus objects, were constructed by embedding a neon bulb in a shaped piece of white plastic. The plastic was covered with black paint leaving only one slit through which light could escape. The slit was of two sizes:

FIGURE 3a

EXPERIMENTAL ROOM

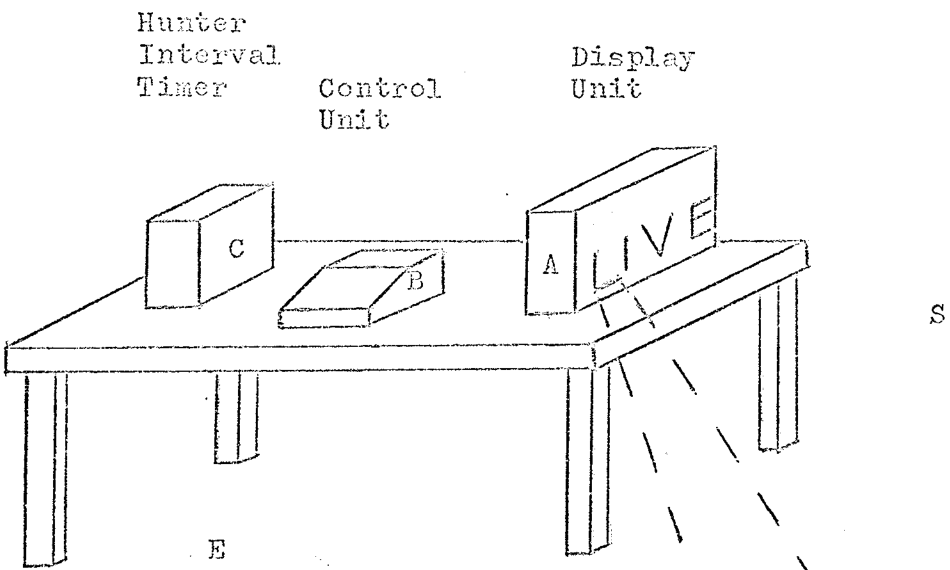
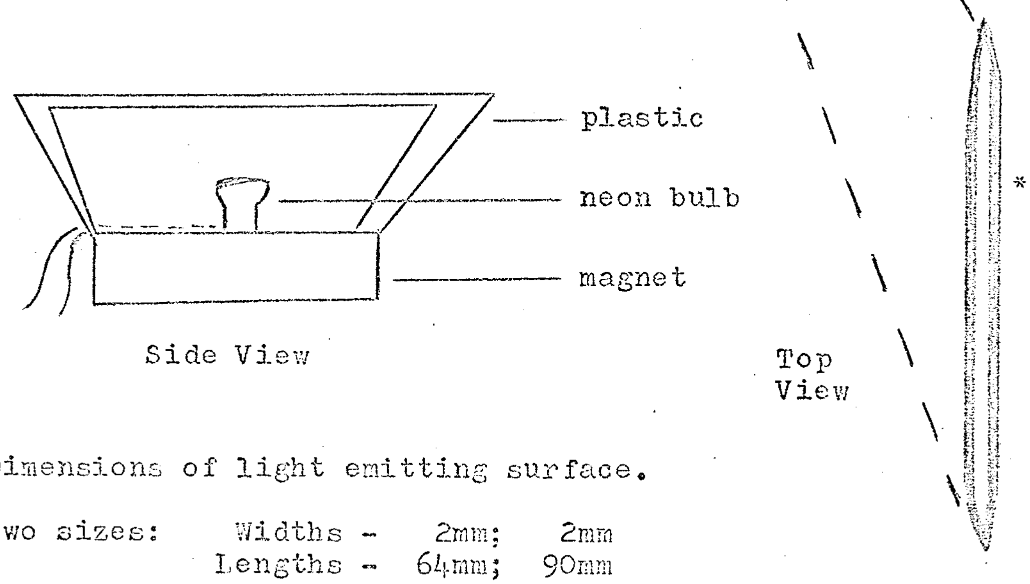


FIGURE 3b

INDIVIDUAL LAMP



* Dimensions of light emitting surface.

Two sizes:	Widths -	2mm;	2mm
	Lengths -	64mm;	90mm

2mm x 64mm, and 2mm x 90mm. Magnets fixed to the base of the plastic allowed these lights to be placed on the metal surface of box A (Figures 3a and 3b). This 12" x 16" box containing electrical outlets and switching circuits, served then, as a backboard on which the lights could be placed together to form different figures. The metal background was painted mat black; and although ultra violet lighting was required to assure consistent firing of the neon bulbs, S could see the position of each light only during firing. A further precaution was taken, however, by placing a cloth screen over the stimulus array between trials.

Stimulus Objects

Six words were used, each constructed from 9 lights. They were: LIVE, NUN, WILL, FUN, MITT, VILE. It can be seen why two light sizes were necessary - the letters V, N, W, and M require longer lengths to complete the diagonals.

Two horizontal arrays were used (Figure 4). HA_1 and HA_2 were considered identical forms, for the singular difference between them is a change in the position of an identifying gap. In other features they are identical. All lights in HA_1 and HA_2 were 2mm x 64mm.

Experimental Design

Both W and HA forms were presented sequentially under two conditions. During natural presentation (condition N) the lights creating the various forms flashed on and off in an orderly and sequential fashion from left to right (Figure 4, upper numerals). During random presentation (condition R) the lights were fired in a random order (Figure 4, lower numerals). The same random order of presentation was maintained for the 6 words and 2 horizontal arrays.

The rationale is given in greater detail elsewhere. Basically, natural presentation is not expected to result in a significant pattern of correlation between integration thresholds and the cognitive tests, for both W and HA. However, during random presentation the resultant correlations are expected to a) remain stable for HA in relation to the correlations produced by HA(N), but b) rise significantly for W, in relation to the correlations produced by W(N); this last event (b) replicating the results of den Heyer. The main findings will refer, therefore, to a whole pattern of correlations, and to the differential rise in covariation, if any, from W(N) to W(R), but not from HA(N) to HA(R).

The design called for two sets of words (LIVE, NUN, WILL and FUN, MITT, VILE), and two forms of HA (HA_1 and HA_2). Ss could not, of course, be given the same items during conditions N and R. Therefore, 3 words and one form of HA would be given under N, and the remaining words and HA given to the same Ss the next day under R. Some counterbalancing would then have to be done for position effects.

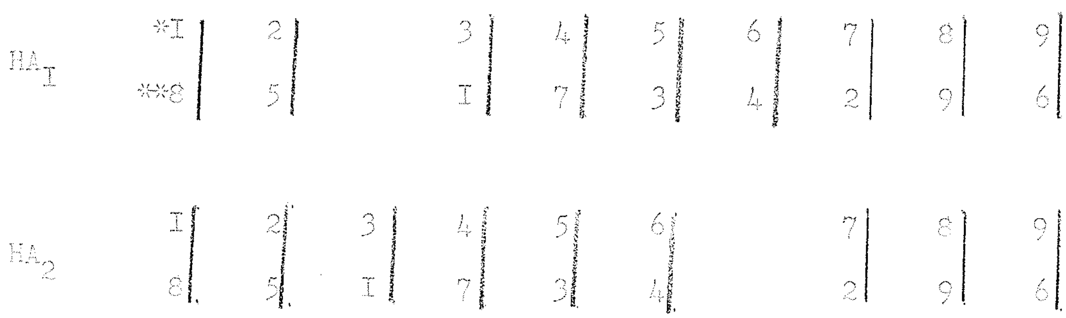
Ss were randomly divided into 2 equal groups (N = 29). Group I received HA_1(N) on Day I, and HA_2(R) on Day 2. Group II received HA_1 (R) on Day I, and HA_2(N) on Day 2. Assuming, for the present purpose of obtaining integration thresholds, the equivalence of HA_1 and HA_2, the only requirement was to counterbalance position effect for N and R.

Reasoning was somewhat different for the words. It could not be as readily assumed that the two sets of words would be equivalent,

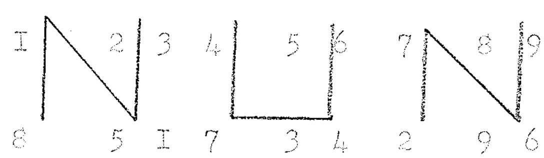
FIGURE 4

VISUAL FORMS APPEARING DURING SPP

Horizontal Array



Verbal Forms (One Example)



Numbers refer to sequence in which lights are presented.

* Natural Sequence

** Random Sequence

i.e., integrated at equal thresholds under the same conditions, even though some attempt was made to have them as similar as possible, e.g., LIVE and VILE, FUN and NUN, WILL and MITT. Some attempt would have to be made to test their equivalence. Thus LIVE, NUN, WILL, and FUN, MITT, VILE, appeared on the first day for Groups I and II, respectively--both under condition N. And during Day 2, each group received the words not previously presented--both under condition R. The difficulty of the words themselves was of interest here, therefore it was important to counterbalance for time of occurrence. The fact that, for the words, R always occurs on the second day of testing, did not appear to have any important bearing on the results; although a full design would have called for 4 groups, and a consequent rise in testing time.

Test Materials

Since the present study is an attempt at further analysis of the results presented by Springbett, on the Lines Test, and by den Heyer, on perceptual integration, essentially identical cognitive tests are used.

Both Springbett and den Heyer had used the Henmon Nelson Test of Mental Ability (den Heyer utilizing Form A). It was decided to continue the use of the Henmon Nelson (HN), Revised Edition, Form A. Three scores can be derived from this test: Verbal IQ, Quantitative IQ, and Total IQ, or V plus Q. These formed variables 1, 2, and 3, respectively.

A shortened form of the Embedded Figures Test (EFT) was used which included the following 12 figures: D_2, E_1, H_1, A_3; C_2, B_1, E_3, G_1, A_2, D_1, C_1, and G_2--given in that order for each S. Scores on EFT constituted variable 4.

The Differential Aptitude Test for Spatial Ability (D.A.T. SA) was the third test given. It is divisible into three parts: Rights, Wrongs, and Total, creating variables 5, 6, and 7, respectively.

Finally, the Differential Aptitude Test for Abstract Reasoning (D.A.T. AR) was included. There are three parts to this test also: Rights, Wrongs, and Total, which becomes variables 8, 9, and 10, respectively.

Subjects

Only male Ss were used. There were 58 students from the University of Manitoba. Participation in such experiments was a course requirement for those enrolled in introductory psychology.

Procedure

Conventional Tests. Before Christmas, the majority of Ss completed the EFT and D.A.T. SA and AR. While individual testing is required for EFT, one group session was used for both SA and AR. After Christmas, HN IQ was administered in group session, each group containing 26 Ss. Appropriate instructions were followed in each case. Those missing any of the group tests completed them individually at later dates.

At this point the conventional tests comprise variables 1 to 10 inclusive. Variables 11 to 22 are derived from the following perceptual integration tasks.

Perceptual Integration Test. For tests utilizing the perceptual integration apparatus, each S came twice, on consecutive days. The stipulation of returning on the following day was fulfilled by all but a few Ss.

Upon entering the experimental room for the first time, S was seated in front of the display unit and given the following instructions:

> Behind the black screen in front of you are a number of very thin lights (S shown sample light). These lights may be put in any combination to form different figures or words. They can also be made to flash independently at a slower or faster rate. Now when I lift the screen the lights will begin flashing on and off. Your task will be to discover the true form outlined by the lights.
>
> They will only flash for periods of 10 seconds. At first you will not be able to recognize any pattern or shape. If not, on the next 10 second trial the lights will flash at a faster rate. You will often notice that lights will appear to jump around, although they are stationary. This effect is called apparent motion and will eventually disappear, at which time the true figure will emerge as a recognizable whole. These 10 second trials will be repeated until you describe the figure exactly as it is.
>
> There will be 4 different figures. The first will be a meaningless one (HA). The last three will be words. It will be necessary for you to reproduce the first figure on a piece of paper so that I can verify that you have seen it correctly. Reproduce the exact number of lines you see, and the spaces between the lines. With the words you need only say what they are as soon as you recognize them.
>
> Pay attention and try your best. Please do not tell anyone of the nature or content of this experiment.

Depending upon the group he was in, S then completed the four parts of the test for that day. After each failure to correctly reproduce the HA, S was given a fresh, blank paper.

There was a 3 to 4 minute delay between each change of words to allow for their construction. This was done by E moving the magnetized lights into their new positions--the procedure being accomplished beyond S's field of vision. After each 10 second trial in which S failed to perceive the visual form, a cloth screen was dropped in front of the unit and firing frequency was increased in steps of 4 l/s. All 8 forms presented during the two days of testing were begun at the frequency of 8 1/s. No additional instructions were given on the second day of testing.

For each subject the following scores were obtained; variables 11 to 14, 17 to 22, refer to integration thresholds: 11 - HA(N), 12 - HA(R), 13 - combined integration threshold for 3 words (N), 14 - combined integration thresholds for remaining words (R), 17 to 22 - individual thresholds for each word. Variables 15 and 16 were difference scores: 15 - HA(R) minus HA(N) or variable 12 minus variable 11, 16 - combined words (R) minus combined words (N) or variable 14 minus variable 13.

Data was then transferred to punch card form, and all 22 variables were intercorrelated by computer. Correlational matrices were made for Groups I and II taken separately, and for the groups combined. The full correlational matrices may be found in Appendix B.

CHAPTER III

RESULTS

The results are analyzed in three parts. In Part I, the correlation coefficients between perceptual and cognitive tests are presented. Comparisons of the correlations produced, by using HA and W forms under N and R orders of presentation, constitute the main findings of this study. From previous results a basic expectation is for significant correlations of W(R) with Verbal IQ, EFT, D.A.T. Spatial Ability and Abstract Reasoning. The remaining conditions, W(N), HA(N), and HA(R), are not expected to correlate significantly with the same cognitive tests.

Part II gives an analysis of variance of the average integration threshold attained during each of the four perceptual conditions. Since the main results depend upon a comparison of correlation coefficients, the standard deviation within each of these conditions are also compared.

A third part was required because significant differences were found between some group means. It will be remembered that the experimental design called for the use of two groups of subjects, with the expectation that no differences would exist between them. The results in Part I are obtained from a combination of the two groups of results. Part III thus indicates those differences which do exist; and in a sub-analysis of the main results, presents the separate correlation coefficients between perceptual and cognitive variables for Groups I and II. This was done to check whether group differences in means, which occurred in two of the perceptual conditions, appreciably influenced the size of correlation coefficients.

PART I

Correlation Coefficients Between Perceptual and Cognitive Tests

The coefficients displayed below in Table 2, were obtained from the combined data of Groups I and II. Total N was 58, with 29 Ss from each group. Table 2 gives only the 24 correlations between main cognitive variables--Verbal IQ, Quantitative IQ, Total IQ, EFT, D.A.T. SA and AR, and the four perceptual variables--HA(N), HA(R), W(N), and W(R). The full correlational matrix of 256 inter-correlations can be found in Appendix B, Table 8.

TABLE 2

CORRELATION COEFFICIENTS BETWEEN PERCEPTUAL AND COGNITIVE VARIABLES (COMBINED DATA)

Cognitive Variable	Sequential Part Presentation 11 HA(N)	12 HA(R)	13 Words(N)	14 Words(R)
1 Verbal IQ	-.030	-.043	-.176	.055
2 Quantitative IQ	-.195	-.022	-.252*	-.236*
3 Total IQ	-.113	-.041	-.244*	-.071
4 EFT	.099	.268*	.392*	.433*
7 D.A.T. SA	-.200	-.312*	-.309*	-.570*
10 D.A.T. AR	-.365*	.024	-.298*	-.353*

*$p < .05$, df = 56, t>1.671.

Restricting the discussion to significant correlations ($p < .05$, $df = 56$, $t > 1.671$), one finds that HA(N) correlates with D.A.T. AR -.365, HA(R) with EFT .268 and with D.A.T. SA -.312. The correlations for W forms are generally larger than the correlations for HA forms. W(N) has significant correlations of -.252 with Quantitative IQ, -.244 Total IQ, .392 EFT, -.309 D.A.T. SA, and -.298 D.A.T. AR. W(R) correlates -.236 with Quantitative IQ, .433 EFT, -.570 D.A.T. SA, and -.353 with D.A.T. AR.

A definitely unexpected result is the failure of W(R) to correlate with Verbal IQ ($r = .055$). Also unexpected, is the consistent pattern of significant correlations of W(N) with the cognitive tests. In view of this pattern, a significant correlation of W(N) with Verbal IQ would seem approriate, but again, as for W(R), it did not materialize ($r = -.176$).

The correlation coefficients produced by HA forms are consistently in the same direction as those produced by the words, but are generally smaller in size. If an average correlation coefficient (disregarding sign) is taken over the six cognitive variables in Table 2, the results (Table 3) show the r_{av} for HA(N) to be .167, for HA(R) .112, for W(N) .278, and for W(R) .268.

Upon inspection of the correlations on the last three cognitive variables in Table 2 (EFT, D.A.T. SA and AR), one finds that the general influence of a random order of presentation, as compared with a natural order, is to increase the size of the correlations for both HA and W forms. The two most obvious examples are found in the increase of W(N) to W(R)

TABLE 3

r_{av} COMPARISON OF PERCEPTUAL CONDITIONS (FROM TABLE 2)

	Sequential Part Presentation			
	11 HA(N)	12 HA(R)	13 Words(N)	14 Words(R)
r_{av}	.167	.112	.278	.268

from -.309 to -.570, on D.A.T. SA, and of HA(N) to HA(R) from .099 to .268, on EFT. A notable contrary result, however, is the drop in correlation of HA(N) to HA(R) from -.365 to .024, on D.A.T. AR. This unequal influence of R across the three cognitive tests for HA forms, does complicate any possible explanation. It is certainly contrary to expectation, nevertheless, that at least two of the correlations for HA forms (with EFT and D.A.T. SA) do become significant during R, and that a third correlation (with D.A.T. AR) becomes significant during N.

PART II

Integration Thresholds

Again using the combined data from the two groups, an analysis of variance was undertaken to ascertain the effects of the main conditions (sequential order and visual form) on integration thresholds during SPP. Replacing a two-way design, which consisted of correlated data for all cells, a three-way classification scheme was utilized (McNemar, 1962; pp. 322-329). The results, summarized in Table 4 below, indicate what would be expected.

TABLE 4

ANALYSIS OF VARIANCE SHOWING INFLUENCE OF 2 TYPES OF VISUAL FORMS AND 2 SEQUENTIAL ORDERS OF PRESENTATION ON INTEGRATION THRESHOLD DURING SPP

Source of Variation	SS	df	MS	F
HA vs W (1)	13,751	1	13,751	1145*
N vs R (2)	5,821	1	5,821	322*
Subjects (3)	3,080	57	54	
Interaction 1 x 2	2,154	1	2,154	153*
" 1 x 3	703	57	12	
" 2 x 3	1,053	57	18	
" 1 x 2 x 3	830	57	14	
Total	27,392	231		

*$p < .05$

Integration threshold for HA forms is significantly higher than the threshold for the words, viz., mean integration threshold for HA (N), HA (R), Words (N) and (R) are, respectively 25.3, 41.2, 15.5, and 19.9. A random order of presentation also produced significantly higher integration thresholds for both HA and W, although a significant interaction between the two conditions (F = 153) demonstrates an unequal and lesser influence of R for the words. In Part III, the main contributor to this interaction is attributed to one set of words, which are found to give significantly lower integration thresholds during R. When the results from the two groups of subjects are combined, the effect of this set of words is to lower appreciably the total mean integration threshold for W(R), producing the interaction.

The influence of the main conditions on integration threshold is graphically presented in Figure 5 below. The ordinate represents threshold in lights per second (1/s), while the abscissa designates conditions N and R. A point to remember is that all trials began at the frequency of 8 1/s.

An F test comparison of individual variances for all four perceptual conditions, using the combined data, yielded the following results (Table 5). Condition R generally results in an increase in

TABLE 5

VARIABILITY OF SCORES DURING SPP

	Sequential Part Presentation						
	11 HA(N)		12 HA(R)		13 Words (N)		14 Words (R)
Standard Deviations	4.9		6.3	*	3.1	*	5.0
		*					

*p < .025, df = 57 & 57, F = 1.67.

FIGURE 5

AVERAGE INTEGRATION THRESHOLD FOR HA AND W FORMS UNDER N AND R ORDERS OF PRESENTATION

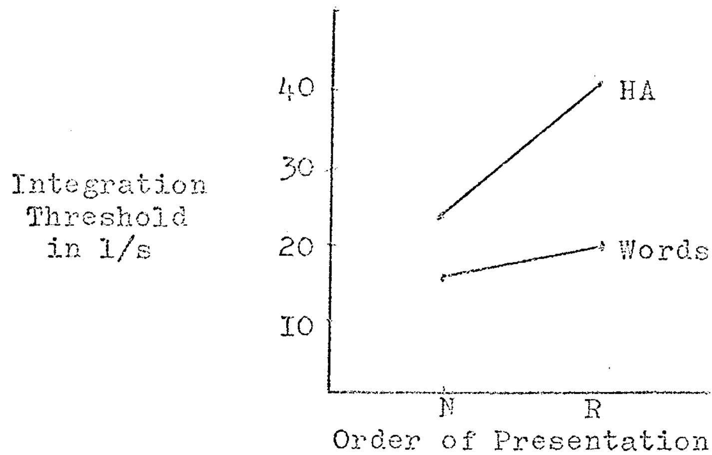
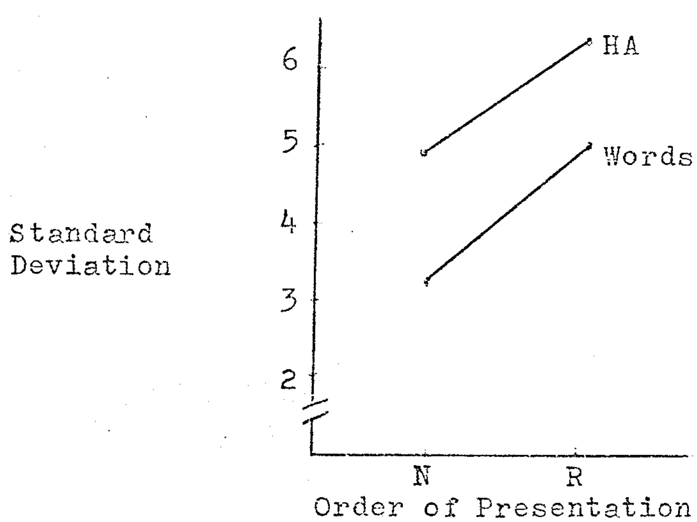


FIGURE 6

VARIABILITY OF SCORES FOR HA AND W FORMS UNDER N AND R ORDERS OF PRESENTATION



variability which is significant for the words only. The variability for W(R) is significantly greater than for W(N), 5.0 vs 3.1; however, the variability of HA(R), although greater than that of HA(N), 6.3 vs 4.9, is not significantly larger. Both HA forms also result in significantly greater variability than W(N), 4.9 and 6.3 vs 3.1. These results are produced graphically in Figure 6.

A noteworthy finding, considering the results in Part I, is that W(N) and W(R) maintain higher correlation coefficients with cognitive tests, in spite of comparable and, in fact, lower variability.

In summary, the results in Part II demonstrate a) increased integration threshold under HA and R conditions, and b) increased variability under those same conditions.

PART III

Group Differences

Because each S partook in the task of integrating HA and W forms under both conditions N and R, it was necessary to supply different HA and verbal forms during the second condition. Otherwise S would soon realize that the same items were being used, and the purpose of the experiment would be defeated. The two types of HA forms used were considered identical, therefore Ss were divided into two groups to alternate the order of appearance for conditions N and R only. The two different sets of words, each to be used under a separate condition, could not as easily be considered identical, however, and the same two subject groups were then used to insure that each set of words appeared under similar conditions. In this way one can compare different verbal forms in relation to either integration threshold, or, to the resulting correlations with cognitive tests, since correlation coefficients between perceptual and cognitive variables were taken within Groups I and II separately, before the results were combined for the main findings.

Surprisingly, significant differences between the groups were found in the mean integration threshold of HA forms during N, and in the integration thresholds of W forms during R ($p < .025$, $df = 56$, $t > 2.00$). Table 6 below, gives a comparison of those means. Average integration threshold for Group I on HA(N) was 27.4, and for Group II it was 23.17. The average integration threshold for Group I on W(R), which consisted of the word set FUN, MITT, VILE, was 21.3, and for Group II, which received the word set LIVE, NUN, WILL, it was 18.5. Bracketed numbers in the table referred to the day on which the different forms appeared, i.e., whether it was first or second session.

TABLE 6

AVERAGE INTEGRATION THRESHOLDS FOR GROUPS I AND II

	Sequential Part Presentation			
	11 HA(N)	12 HA(R)	13 Words (N)	14 Words (R)
Gr I	(1) 27.4	(2) 40.2	(1) LIVE NUN WILL 15.9	(2) FUN MITT VILE 21.3
Gr II	(2) 23.1	(1) 42.2	(1) FUN MITT VILE 15.9	(2) LIVE NUN WILL 18.5

No significant differences between Groups I and II were found, on the average scores for the remaining cognitive variables (variables 1 to 10).

Finally, Tables 7a and 7b give the separate correlation coefficients between perceptual and cognitive variables for Groups I and II. The entire correlation matrices for both groups can be found in Appendix B, Tables 9 and 10. In relation to the group differences in mean integration thresholds for HA(N) and W(R), there appears to be no effect on correlation as a result of different thresholds. The r_{av} on HA(N) in Group I is .163, and for Group II .244 (Table 7a). The r_{av} on W(R) for Group I is .332, and for Group II, .231. However, where the group means are similar, on HA(R) and W(N), there exist larger deviations between groups, in the size of correlation coefficients. Thus, on HA(R) Group I has an r_{av} of .185, and Group II -.013. In this last instance, Group II gives the largest number of correlations in a direction opposite to the majority of correlations, although none of these are significant.

The r_{av} for Group II on W(N) is more than twice that of Group I, .368 vs .167. In a detailed look at this discrepancy, the most notable characteristic is the difference between the groups on the correlations with EFT. Group I has a correlation coefficient of .017 and Group II .676. For W(N), Group I received the word set LIVE, NUN, WILL, and Group II the set FUN, MITT, VILE. Under W(R) each group received the opposite set. An additional peculiarity is discovered upon inspection of the correlations yielded by the word MITT. Under condition N, a correlation of .727 is obtained with EFT, but during condition R the correlation drops to .157 with the same cognitive test--a direct reversal of the expected results.

TABLE 7a

CORRELATION COEFFICIENTS BETWEEN PERCEPTUAL AND COGNITIVE VARIABLES (GROUP I)

	Sequential Part Presentation			
Cognitive Variables	11 HA(N)	12 HA(R)	13 Words(N)	14 Words(R)
1 Verbal IQ	-.067	-.101	-.025	-.076
2 Quantitative IQ	-.193	-.196	-.232	-.297
3 Total IQ	-.145	-.172	-.136	-.205
4 EFT	.026	.181	.017	.349*
7 D.A.T. SA	-.259	-.361	-.257	-.606*
10 D.A.T. AR	-.290	-.101	-.336*	-.461*
r_{av}	.163	.185	.167	.332

*$p < .05$, $df = 27$, $t > 1.703$

TABLE 7b

CORRELATION COEFFICIENTS BETWEEN PERCEPTUAL AND COGNITIVE VARIABLES (GROUP II)

	Sequential Part Presentation			
Variables	11 HA(N)	12 HA(R)	13 Words(N)	14 Words(R)
1 Verbal IQ	-.245	.136	-.304	.056
2 Quantitative IQ	-.205	.242	-.270	-.158
3 Total IQ	-.267	.202	-.331*	-.031
4 EFT	.223	.420*	.676*	.619*
7 D.A.T. SA	-.084	-.308	-.358*	-.528*
10 D.A.T. AR	-.431*	.227	-.273	-.106
r_{av}	.244	-.013	.368	.231

*$p < .05$, df = 27, t = 1.703.

CHAPTER IV

DISCUSSION

The purpose of this experiment was to isolate, if possible, the factors determining covariation between a perceptual task (SPP) and several cognitive variables.

One hypothesis stated that differences in a basic neural mechanism or 'processing period' create certain abilities which become demonstrable in different cognitive tests. In the case of SPP, where apparent motion appears to play an important role, it was argued that either the rates of presentation interact with, or the perception of AM is related to, this processing period. Covariation between SPP and cognitive tests is the direct result of this common neural mechanism.

A second hypothesis proposed that the covariation with tests such as Verbal IQ and D.A.T. Spatial Ability, is explained by the existence of common organizational features found in both cognitive tests and certain SPP figures. As a continuation of the Lines Test, the SPP technique was also thought to simulate other cognitive tests such as EFT and D.A.T. Abstract Reasoning. Essential to all three tests is the task of discovering a hidden organization or principle.

The pattern of results obtained in this experiment, although not conclusive, would appear to favour the latter hypothesis.

It is the verbal figures, consisting of familiar organizations, which produce more consistent correlations with cognitive tests than does a meaningless and uniform structure such as the horizontal array. The size of correlation coefficient produced by verbal forms is substantially greater than the correlations produced by HA forms. Average correlation for W(N) and W(R) is .278 and .268 respectively, while those for HA(N) and HA(R are .167 and .112 (Table 3). Nine out of a possible twelve correlations were significant for the meaningful forms while for HA forms three out of twelve were significant (Table 2). Considering that HA forms were not expected to correlate with Verbal IQ in any case, and omitting also the correlations with Total IQ, the HA form actually correlates significantly with three out of eight tests.

The existence of significant correlations with cognitive tests, even on such a simple form as the horizontal array, still holds open the possibility that 'pure' AM reduction is a factor in determining covariation. This is supported in turn, by the failure of W(N) or W(R) to correlate with Verbal IQ. If superiority in verbal organization cannot be related to performance on SPP for verbal figures, some doubt is cast upon the importance of meaningful organization for the reduction of AM.

A possible explanation of this failure to obtain significant correlation with Verbal IQ, a result achieved by den Heyer (Table 1), is that Ss in both experiments were given different instructions. Whereas den Heyer's Ss were not told to expect words, the instructions in the present study explicitly stated that words would be used. The consequence of changing S's expectation can be seen in Figure 7. Integration threshold on verbal figures presented in random sequence, was 26 l/s in den Heyer's study, and 19.9 l/s in this one. The more difficult condition, in the former case, would probably account for the more significant correlations of verbal figures with Verbal IQ.

The Influence of N and R Orders of Presentation

The analysis of variance in Part II of the Results shows a) a significantly lower integration threshold for verbal forms in relation to HA forms, and b) a significant rise in integration threshold for HA forms during condition R, but an insignificant rise in integration threshold for verbal forms under the same condition (Figures 5 & 7). Thus, there is an interaction between the two main conditions of visual form and order of presentation.

The rise in integration threshold for the words, although insignificant, and for HA forms, following the change from a natural to a random order of presentation, is most reasonably explained as a result of a difference between N and R in the occurrence and persistence of AM. A change from a natural to random sequence results in a change in the temporal and spatial relationship between lights, and thus a change in the time, i.e., in rates of firing, when optimal AM occurs between lights. For a random sequence, optimal AM between various lights probably occurs within a wider range of presentation speeds. It is also known that AM is more persistent when the stimuli are randomly presented, in contrast to the situation where directional information is high.

The underlying neural organization which is responsible for normal verbal cognition is probably the factor responsible for the overall lower integration threshold for verbal forms in this experiment. The existence of this meaningful organization, for reducing AM during both natural and random sequences, would also appear to be an important factor in determining covariation with the cognitive tests, since the correlations on verbal forms are superior to and more consistent than, those for the horizontal array. Under the condition where AM is more persistent and disrupting (condition R), there is a greater ability of the test to discriminate between Ss. What was unexpected, was that condition N would display a similar capacity for the words.

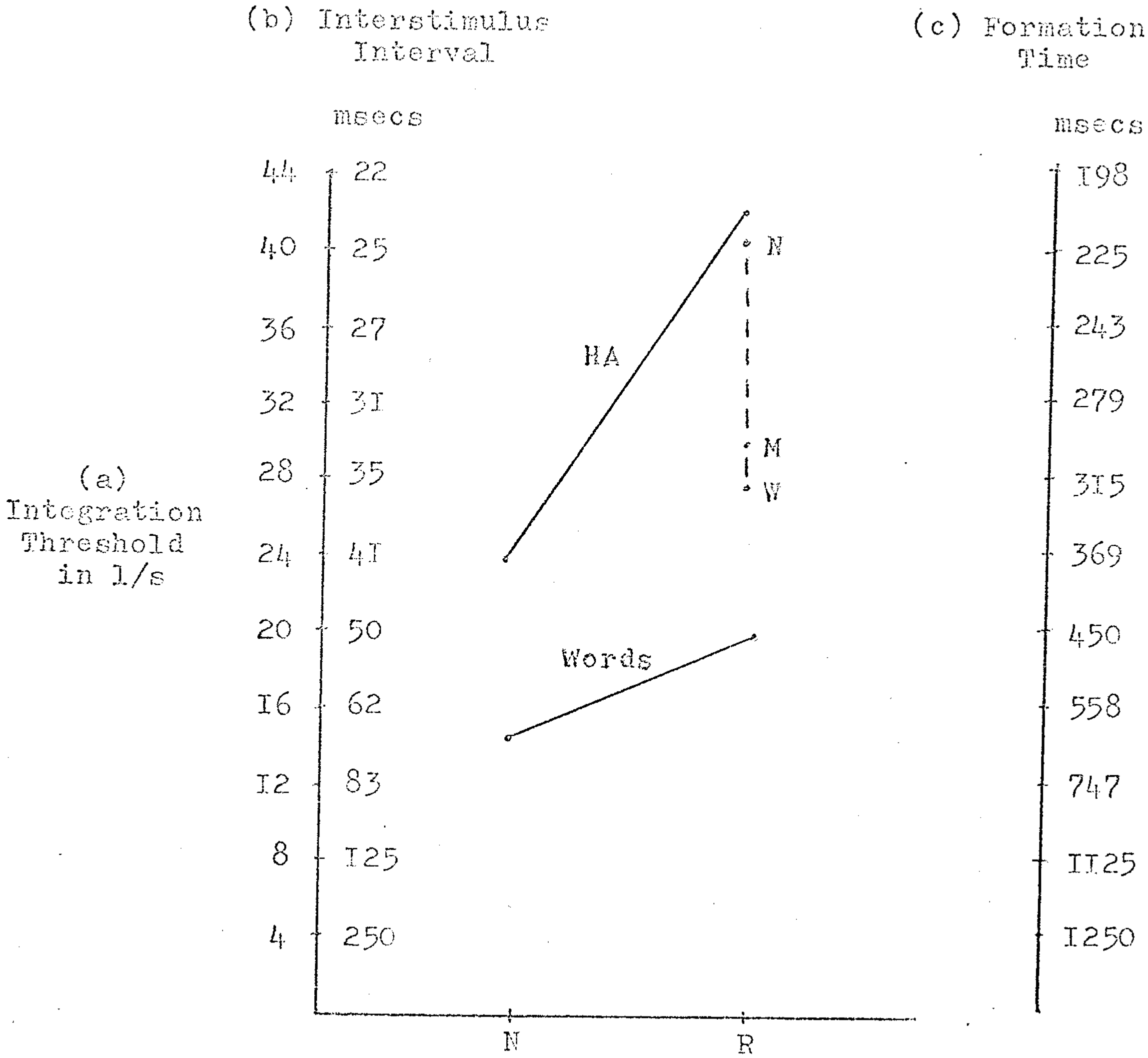
Although the horizontal array also produces higher correlations during condition R, with EFT and D.A.T. Spatial Ability, the trend is reversed in the correlation with D.A.T. Abstract Reasoning, where the natural sequence produced a higher correlation (-.365 vs .024). It is mainly because the results for HA forms are inconsistent, though showing some signs of covariation, that the latter hypothesis stressing the importance of meaningful organization is favoured.

The Two Experiments Compared

The results from the experiment by den Heyer (1967) and from the present study, are placed together in Figure 7. A total of five different visual forms have been tested to this date: nonsense (N), meaningful (M), and verbal(W) figures, presented under a random sequence in den Heyer's study (connected by the dotted line), and verbal and HA forms, presented under natural and random sequences in the present study (connected by continuous lines). Because of interest in the concept of a 'processing period', the ordinate presents three ways of viewing the data: '(a)' indicates integration threshold in lights per second, for each form,

FIGURE 7

THE TWO EXPERIMENTS COMPARED



The abscissa designates natural (N) or random (R) order of presentation. The ordinate designates either a) integration threshold in lights per second; b) the interstimulus interval between successive lights, in milliseconds; c) the formation time that an entire figure of 9 lights will take under the rates of presentation in (a).

'(b)' represents the interstimulus intervals between lights, in milliseconds, which would occur under the rates of presentation in (a), '(c)' represents, in milliseconds, the time required (formation time) to present an entire figure of nine lights, remembering that in both studies each trial consisted of a ten second duration, in which case each figure is presented many times.

There are two important points to observe. First, as mentioned previously, there is the difference in integration threshold between comparable verbal forms in the two experiments. In the experiment where Ss expected words, integration threshold is much lower.

Second, there is the comparison of what are basically two different types of nonsense figures; the N figures in den Heyer's study which consisted of spread out, non symmetrical designs, and the horizontal array in the present study, which consisted of a uniform, near symmetrical pattern. Although they are similar in integration threshold, den Heyer's figures give superior correlations with the cognitive tests common to both experiments - EFT .318 vs. .268, and D.A.T. Spatial Ability - -.625 vs. -.312. All correlations were significant.

To account for the covariation achieved with a nonsense figure, den Heyer had suggested that throughout the many trials (approximately 8) S gradually learns or builds up an internal representation of the form. The reduction of AM would depend upon how susceptible each S is to the organization which has been developing. It may also be, however, that it is difficult to escape from spatial organization of some kind, regardless of the figure used; thus there may always be some covariation with certain cognitive tests, as was found with the HA form in this experiment.

An incidental finding in the present study concerns the wide variation in integration thresholds and correlation coefficients for the words. Part III of the Results deals with the significant difference found between integration thresholds for the word sets LIVE, NUN, WILL, and FUN, MITT, VILE, both under condition R. The main contributors to this result are the words LIVE and VILE, which have integration thresholds of 14.2 and 20.6 respectively. Under condition N, LIVE also gives lower integration thresholds than VILE, 13.9 vs 17.6. Perhaps word usage or familiarity has an appreciable influence on integration threshold.

Upon comparing the integration thresholds with correlation coefficients to see if one had any effect upon the other, no definite relationship could be discovered. However, certain words were found to produce idiosyncratic results. NUN, for example, had average correlations of .040 during N and .079 during R, with the six cognitive variables given in Table 2. Its 'sister' word FUN, produced much higher average correlations of .272 and .233 with the same cognitive tests during conditions N and R. Meanwhile, as mentioned in Part III, MITT correlated with EFT .727 during N, and .157 during R - a direct reversal of the main body of results where R yielded the higher correlations.

Therefore, although the words generally produce significant covariation with cognitive tests, it may be worthwhile to consider carefully the relationship between word familiarity and word shape, and the size of correlation which one expects to receive.

Methodological Considerations

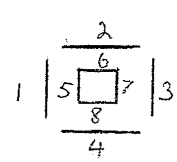
The presentation of parts of visual forms started at the rate of 8 1/s, and increased in steps of 4 1/s after every trial. It is possible that such a scoring system, in contrast to one in which increments would be in the order of 1 1/s, reduces the size of correlation which could be attainable under a more continuous method. Since definite covariation can be demonstrated using the present method, the results appear in an even more favourable light.

It is also significant that this covariation is maintained even though different instructions were given to Ss, and in spite of a difference in the size of the lights used in constructing the forms. Opportunities for additional research using this technique would appear to be plentiful.

Additional Areas of Research

Since the horizontal array did yield at least three significant correlations, any definite statement concerning the role of 'pure' AM reduction is still improper at this time. It may be well to conduct a study which would relate apparent motion threshold on just two lights, with the results from the same cognitive tests used in this study, and also with integration threshold on SPP.

An example of the continuous link between the two phenomena of apparent motion and perceptual integration occurs in the case of the following form



which is constructed from neon lights and presented sequentially as indicated by the numbers. At a low frequency (12 1/s) the form is unrecognizable. At about 16 1/s, AM begins to occur in a holistic fashion wherein the form appears to expand and contract into a larger and smaller square. Finally, at about 24 1/s, the form stabilizes and can be perceived correctly. Only a few preliminary Ss have been tested on this form, but it gives an excellent illustration of the continuity of AM cessation and immediate perceptual integration. A suggested study would involve running ascending and descending trials on such a figure, to discover whether a descending method (measuring form retention) yields better correlations with cognitive tests than an ascending one (measuring AM reduction), or whether, in fact, their effects regarding correlations are identical.

A study is also being considered which will utilize only a single cycle or sweep of sequential firing across the whole form, in contrast to the last two experiments which used repeating cycles of 10 second duration.

A final possibility is to present a figure, for example a word, in an abbreviated but recognizable form consisting either of straight lines or angle parts. The procedure would have some bearing on the research and theory of McFarland (1961, 1965, 1968) concerning analysis and integration in form perception.

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APPENDIX A

DESCRIPTION OF APPARATUS

The following description is reproduced from den Heyer (1967):

The main components of the apparatus can be described as a display unit, control unit, and a Hunter Interval Timer (HIT). (Bell personal communication).

The display unit contains the 9 stimuli or figures to be presented to the Ss (see FIGURES 3a and 3b). Associated with the display unit is a multipole-multiposition switch to select the group of lights comprising each figure as required and the electronic circuitry of a neon glow lamp ring counter (Manley & Buckly, 1950; G. E. Glow Lamp Manuel, 1956). The neon glow lamps - YAC, ME 97 (G. E. Glow Lamp Manuel, 1956) - are housed in clear plexiglass with visible face dimensions of 2mm X 64mm or 2mm X 90mm*. The rest of the underhousing has a coating of white and a surface coat of black to prevent both visibility and loss of light.

The control unit, operated from 117 V, 60 HS (c/s) source provides a regulated D. C. voltage to energize the neon lights. A SCR operated multivibrator provides a 70 V square wave signal to fire and extinguish each light in turn. A multipole-multiposition switch was used to control changes in frequency in either steps of 3, 4 or 5 c/s. The on:off ratio was set at 1:1 .

The HIT was used to control trial interval for both natural and random SPP.

During the operation of apparatus a source of ultra-violet light was used. Insofar as the neon lights are photosensitive the uv light served to insure regular sequential operation (Engel & Novat, 1966).

* The dimensions cited here are larger than those originally used in the study by den Heyer.

APPENDIX B

TABLE 8

CORRELATIONAL MATRIX GROUPS I AND II COMBINED

	I	2	3	4	5	6	7	8	9	I0	II	I2	I3	I4	I5	I6
I																
2	.406															
3	.904	.758														
4	.0I4	-.088	-.03I													
5	.I65	.3I9	.268	-.496												
6	-.057	-.I30	-.I0I	.2I2	-.I88											
7	.I46	.300	.244	-.498	.87I	-.637										
8	-.I29	.387	.089	-.307	.428	-.I35	.376									
9	-.0I8	-.294	-.I50	.I50	-.093	.I78	-.I20	-.523								
I0	-.II3	.393	.I04	-.295	.394	-.I56	.354	.986	-.650							
II	-.030	-.I95	-.II3	.099	-.I84	.I09	-.200	-.350	.305	-.365						
I2	-.043	-.022	-.04I	.268	-.I84	.3II	-.3I2	.006	-.I37	.024	.220					
I3	-.I76	-.252	-.244	.392	-.27I	.I59	-.309	-.325	.093	-.298	.423	.375				
I4	.055	-.236	-.07I	.433	-.556	.260	-.570	-.378	.II7	-.353	.428	.465	.5I6			
I5	.0I5	.I42	.077	.I80	-.034	.206	-.I64	.297	-.4I7	.335	-.450	.733	.097	.I37		
I6	.I92	-.090	.095	.2I6	-.446	.I85	-.434	-.20I	.068	-.I9I	.I87	.266	-.I3I	.78I	.688	

Variables:

I Verbal IQ
2 Quantitative IQ
3 Total IQ
4 EFT
5 SA-Rights
6 SA-Wrongs
7 SA-Total
8 AR-Rights
9 AR-Wrongs
I0 AR - Total
II HA(N)
I2 HA(R)
I3 Words (N)
I4 Words (R)
I5 I2 - II
I6 I4 - I3

TABLE 9

CORRELATIONAL MATRIX FOR GROUP I

	I	2	3	4	5	6	7	8	9	I0	II	I2	I3	I4	I5	I6
I																
2	.330															
3	.877	.743														
4	.20I	-.II8	.082													
5	.I06	.424	.29I	-.6I3												
6	.028	-.280	-.I23	-.092	-.I98											
7	.027	.469	.289	-.445	.889	-.625										
8	-.408	.350	-.II2	-.468	.478	-.3I7	.529									
9	.20I	-.298	-.009	.3I7	-.324	.343	-.4I8	-.6I4								
I0	-.394	.364	-.095	-.468	.480	-.346	.544	.988	-.725							
II	-.067	-.I93	-.I45	.026	-.235	.I54	-.259	-.257	.3I2	-.290						
I2	-.I0I	-.I96	-.I72	.I8I	-.239	.365	-.36I	-.093	.054	-.I0I	.270					
I3	-.025	-.232	-.I36	.0I7	-.I9I	.224	-.257	-.346	.I78	-.336	.599	.520				
I4	-.076	-.297	-.205	.349	-.574	.3I9	-.606	-.457	.3II	-.46I	.384	.566	.646			
I5	-.059	-.076	-.080	.I6I	-.092	.264	-.I97	.064	-.I35	.075	-.339	.8I5	.I49	.322		
I6	-.082	-.227	-.I74	.44I	-.6I3	.26I	-.6II	-.357	.282	-.369	.093	.380	.I58	.856	.3I5	

Variables:
I Verbal IQ
2 Quantitative IQ
3 Total IQ
4 EFT
5 SA-Rights
6 SA-Wrongs
7 SA-Total
8 AR-Rights
9 AR-Wrongs
I0 AR-Total
II $HA_I(N)$
I2 $HA_2(R)$
I3 Live+Nun+Will(N)
I4 Fun+Mitt+Vile(R)
I5 I2 - II
I6 I4 - I3

TABLE 9 Continued

	I	2	3	4	5	6	7	8	9	I0	II
I7	-.I55	-.I92	-.207	-.022	-.I0I	.003	-.082	-.04I	-.026	-.032	.568
I8	.066	.059	.077	-.050	.0I7	.294	-.I24	-.282	.I8I	-.278	.386
I9	.058	-.364	-.I44	.I0I	-.335	.266	-.394	-.5II	.286	-.50I	.425
20	-.I60	-.049	-.I38	.249	-.4I9	.3I7	-.445	-.274	.287	-.289	.229
2I	.072	-.248	-.075	.I57	-.296	.306	-.384	-.409	.I70	-.399	.288
22	.053	-.365	-.I48	.322	-.572	.237	-.599	-.465	.356	-.474	.220

	I2	I3	I4	I5	I6	I7	I8	I9	20	2I	22
I7	.422	.756	.408	.070	.0I6						
I8	.259	.8I3	.463	.02I	.049	.420					
I9	.5II	.789	.646	.244	.30I	.292	.58I				
20	.297	.374	.792	.I53	.772	.245	.309	.333			
2I	.650	.64I	.744	.426	.529	.475	.50I	.53I	.393		
22	.392	.365	.726	.25I	.692	-.067	.247	.696	.382	.429	

Variables: I7 Live 20 Fun
I8 Nun 2I Mitt
I9 Will 22 Vile

TABLE I0

CORRELATIONAL MATRIX FOR GROUP II

	I	2	3	4	5	6	7	8	9	I0	II	I2	I3	I4	I5	I6
I																
2	.5I9															
3	.924	.806														
4	-.II8	-.065	-.II0													
5	.296	.206	.297	-.402												
6	-.I26	.009	-.084	.467	-.I83											
7	.273	.I26	.246	-.558	.850	-.657										
8	.245	.436	.364	-.I55	.344	.070	.I68									
9	-.295	-.290	-.333	-.028	.227	-.0I2	.268	-.378								
I0	.269	.435	.380	-.I22	.259	.066	.093	.984	-.527							
II	-.254	-.205	-.267	.223	-.052	.097	-.084	-.4I7	.3I9	-.43I						
I2	.I36	.242	.202	.420	-.I59	.262	-.308	.I40	-.5I3	.227	.427					
I3	-.304	-.270	-.33I	.676	-.348	.I08	-.358	-.3I9	.005	-.273	.350	.233				
I4	.056	-.I58	-.03I	.6I9	-.523	.226	-.258	-.I84	-.246	-.I06	.3I9	.456	.439			
I5	.3I0	.387	.388	.207	-.069	.I69	-.239	.56I	-.862	.673	-.360	.6I3	.076	.I76		
I6	.3I9	.073	.253	.044	-.230	.I35	-.226	.088	-.254	.I28	.022	.270	-.4I7	.633	.I20	

Variables:
I Verbal IQ
2 Quantitative IQ
3 Total IQ
4 EFT
5 SA-Rights
6 SA-Wrongs
7 SA-Total
8 AR-Rights
9 AR-Wrongs
I0 AR-Total
I2 HA_I(R)
II HA_2(N)
I3 Fun+Mitt+Vile(N)
I4 Live+Nun+Will(R)
I5 I2 - II
I6 I4 - I3

TABLE I0 Continued

	I	2	3	4	5	6	7	8	9	I0	II
I7	-.33I	-.I37	-.290	.437	-.I45	.I06	-.I86	-.278	.069	-.253	.46I
I8	-.083	-.27I	-.I79	.727	-.286	.073	-.288	-.289	-.074	-.234	.3I2
I9	-.320	-.I92	-.307	.357	-.342	.077	-.329	-.I70	.038	-.I49	.069
20	.022	-.306	-.I5I	.480	-.43I	.294	-.486	-.287	-.06I	-.248	.I75
2I	.046	.I44	.096	.456	-.293	.I03	-.287	-.080	-.303	-.0I7	.302
22	.080	-.I60	-.0I6	.333	-.34I	.080	-.309	-.030	-.I34	.024	.I74

	I2	I3	I4	I5	I6	I7	I8	I9	20	2I	22
I7	.220	.763	.335	-.066	-.3I8						
I8	.352	.805	.503	.I59	-.I84	.493					
I9	-.04I	.730	.I57	.028	-.470	.36I	.300				
20	.245	.300	.594	.094	.343	.I05	.423	.II8			
2I	.587	.323	.699	.262	.428	.4II	.37I	-.0I4	.I85		
22	.I34	.269	.7I8	.0I5	.494	.I65	.244	.I99	.I00	.248	

Variables: I7 Fun, I8 Mitt, I9 Vile, 20 Live, 2I Nun, 22 Will

APPENDIX C

TABLE II

RAW SCORES FOR SPP - GROUP I

S	Day I (Natural) HA_I(N)/Live	Nun	Will	Sum Words		Day 2 (Random) HA_2(R)/Fun	Mitt	Vile	Sum Words
I	36	20	I6	I6	52	52	20	24	I6	60
2	36	28	20	I6	64	44	24	28	28	80
3	28	I6	I6	I2	44	40	8	24	I6	48
4	28	I6	I6	20	52	48	32	20	28	80
5	24	I2	I6	20	48	44	I6	24	32	72
6	25	I2	20	I6	48	40	24	24	24	72
7	28	20	20	I6	56	36	24	28	I6	68
8	32	I2	20	20	52	40	I2	28	32	72
9	32	I2	20	20	52	40	36	24	32	92
IO	28	I2	I6	I6	44	44	I6	I6	I2	44
II	20	I2	I6	I2	40	24	8	I2	I2	32
I2	I6	8	I2	8	28	40	I2	I6	I2	40
I3	28	8	I2	I2	32	32	28	I2	24	64
I4	28	I2	20	I2	44	40	32	28	20	80
I5	28	I6	20	I6	52	36	28	32	I6	76
I6	24	I2	I6	I2	40	40	I6	20	24	60
I7	24	8	I6	I2	36	20	8	I2	I2	32
I8	28	I6	24	20	60	52	24	28	24	76
I9	24	I2	I6	I6	24	40	28	24	I6	68
20	24	I6	I6	I6	48	52	24	36	28	88
2I	24	I6	20	I6	52	48	I6	28	I2	56
22	24	I6	20	20	56	44	28	28	28	84
23	20	8	I6	I2	36	32	I2	I6	20	48
24	28	I2	I6	I6	44	40	I2	24	20	56
25	28	I6	24	I6	56	32	24	I6	I6	56
26	36	I6	I6	I2	44	32	I6	20	I6	52
27	32	I2	20	24	56	44	8	24	28	60
28	28	I2	20	I2	44	44	I2	20	I6	48
29	32	I6	24	24	64	48	28	32	32	92

TABLE I2

RAW SCORES FOR SPP - GROUP II

	Day I (Natural)					Day 2 (Random)				
S	HA_I(R)/Fun	Mitt	Vile	Sum Words		HA_2(N)/Live	Nun	Will	Sum Words	
I	44	20	I6	20	56	36	I2	I2	8	32
2	32	I2	8	I2	32	24	I2	I6	20	48
3	44	I6	I6	20	52	28	I2	28	44	84
4	44	I6	I2	24	52	25	I6	I6	28	60
5	44	I2	8	20	40	20	8	24	20	52
6	44	I6	I6	I6	48	24	24	20	24	68
7	40	24	I6	28	68	24	I2	20	28	60
8	48	I2	I2	I2	36	24	I6	24	28	68
9	48	I2	I2	I6	40	24	8	I6	24	48
IO	40	I6	I6	I2	44	20	I2	I2	28	52
II	48	I6	20	20	56	24	I2	20	24	56
I2	44	I2	I2	I2	36	I6	8	20	I2	40
I3	4I	I2	I2	20	44	28	20	I2	28	60
I4	44	I6	I6	20	52	20	32	20	20	72
I5	48	24	20	20	64	28	I6	28	32	76
I6	40	I6	I6	I6	48	24	I2	20	20	52
I7	48	I6	24	I6	56	28	I6	24	24	64
I8	40	I2	8	I6	36	I6	I2	I2	I2	36
I9	36	I2	8	I2	32	20	I2	I2	20	44
20	36	20	20	20	60	20	I6	20	20	56
2I	48	20	I6	20	56	24	I2	24	20	56
22	40	I2	I2	20	44	20	I2	I2	24	48
23	40	I2	I2	I6	40	20	I2	20	20	52
24	44	I6	32	24	72	24	24	24	24	72
25	44	20	I2	I2	44	28	I2	32	I6	60
26	32	I2	I2	28	52	I6	8	I2	20	40
27	40	I2	I2	I6	40	24	I6	I2	20	48
28	36	I6	I6	I2	44	20	8	I2	28	48
29	48	I2	I6	I2	40	24	20	24	20	64

TABLE I3

DATA CORRELATED FROM COGNITIVE TESTS AND SPP

GROUP I

S	Verbal IQ	Quant. IQ	Total IQ	EFT	SA-Rights	SA-Wrongs	SA-Total	AR-Rights	AR-Wrongs	AR-Total	$HA_1(N)$	$HA_2(R)$	Sum Words(N)	Sum Words(R)	I2 - II	I4 - I3
	I	2	3	4	5	6	7	8	9	I0	II	I2	I3	I4	I5	I6
I	47	27	74	24	92	I5	77	43	7	4I	36	52	52	60	I6	8
2	29	I8	47	44	60	4	56	4I	2	40	36	44	64	80	8	I6
3	47	2I	68	20	78	9	69	37	7	35	28	40	44	48	I2	4
4	28	20	48	38	30	23	7	42	8	40	28	48	52	80	20	28
5	50	I4	64	55	42	I8	24	27	8	25	24	44	48	72	20	24
6	48	35	83	25	9I	7	84	44	6	42	28	40	48	72	I2	24
7	29	I0	39	I5	79	24	55	4I	4	40	28	36	56	68	8	I2
8	40	2I	6I	I5	80	22	58	39	4	38	32	40	52	72	8	20
9	38	I4	52	74	49	I4	35	28	II	25	32	40	52	92	8	40
I0	27	2I	48	27	92	II	8I	45	5	43	28	44	44	44	I6	0
II	38	22	60	8	97	3	94	46	4	45	20	24	40	32	4	-8
I2	38	26	64	44	98	2	96	46	4	45	I6	40	28	40	24	I2
I3	37	2I	58	34	7I	I9	52	40	I0	37	28	32	32	64	4	32
I4	32	27	59	47	46	I6	30	43	7	4I	28	40	44	80	I2	36
I5	47	24	7I	I8	78	I6	62	3I	9	28	28	36	52	76	8	24
I6	3I	2I	52	36	56	5	5I	43	3	42	24	40	40	60	I6	20
I7	5I	30	8I	43	78	I0	68	3I	4	30	24	20	36	32	-4	-4
I8	30	23	53	2I	88	26	62	35	4	34	28	52	60	76	24	I6
I9	3I	23	54	40	62	I5	47	33	4	32	24	40	44	68	I6	24
20	27	20	47	34	62	22	40	38	5	36	24	52	48	88	28	40
2I	44	24	68	47	8I	I0	7I	42	3	4I	24	48	52	56	24	4
22	50	29	79	63	60	I	59	35	3	34	24	44	56	84	20	28
23	33	2I	54	II	79	I4	65	45	I0	42	20	32	36	48	I2	I2
24	46	26	72	68	60	4	56	37	5	35	28	40	44	56	I2	I2
25	35	36	7I	I6	96	4	92	44	5	43	28	32	56	56	4	0
26	30	2I	5I	49	55	I	54	34	I5	30	36	32	44	52	-4	8
27	30	I5	45	7	68	8	60	39	5	37	32	44	56	60	I2	4
28	44	27	7I	27	7I	46	25	40	5	38	28	44	44	48	I6	4
29	49	I5	64	78	53	35	I8	I9	30	II	32	48	64	92	I6	28

TABLE I4

DATA CORRELATED FROM COGNITIVE TESTS AND SPP

GROUP 2

	Verbal IQ	Quant. IQ	Total IQ	EFT	SA-Rights	SA-Wrongs	SA-Total	AR-Rights	AR-Wrongs	AR-Total	$HA_2(N)$	$HA_I(R)$	Sum Words(N)	Sum Words(R)	I2 - II	I4 - I3
S	I	2	3	4	5	6	7	8	9	IO	II	I2	I3	I4	I5	I6
I	I7	I5	32	I7	87	9	78	34	I4	30	36	44	56	32	8	-24
2	28	I7	45	23	73	8	8I	28	2I	22	24	32	32	48	-8	I6
3	4I	23	64	38	7I	9	62	43	7	4I	28	44	52	84	I6	32
4	40	24	64	23	6I	I7	44	46	3	45	24	44	52	60	20	8
5	35	22	57	II	77	7	70	4I	3	40	20	44	40	52	24	I2
6	40	I8	58	I7	65	I	64	30	I	29	24	44	48	68	20	20
7	I8	22	40	64	38	25	I3	32	8	30	24	40	68	60	I6	-8
8	37	33	70	6I	46	8	38	44	3	43	24	48	36	68	24	32
9	33	29	62	48	84	43	4I	43	6	4I	24	48	40	48	24	8
IO	35	I8	53	25	9I	IO	8I	44	6	43	20	40	44	52	20	8
II	34	26	60	75	9I	I4	77	44	5	42	24	48	56	56	24	0
I2	33	22	55	I2	8I	2	79	49	I	48	I6	44	36	40	28	4
I3	23	I2	35	43	85	I7	68	38	I2	35	28	40	44	60	I2	I6
I4	29	I7	46	87	6I	47	I4	44	6	42	20	44	52	72	24	20
I5	2I	I7	38	66	62	I2	50	33	2	32	28	48	64	76	20	I2
I6	43	29	72	4I	88	20	68	4I	9	38	24	40	48	52	I6	4
I7	33	22	55	62	68	I2	56	36	3	35	28	48	56	64	20	8
I8	39	36	75	9	97	2	95	44	5	42	I6	40	36	36	24	0
I9	56	27	83	IO	87	6	8I	39	5	37	20	36	32	44	I6	I2
20	20	20	40	49	65	II	54	40	IO	37	20	36	60	56	I6	-4
2I	54	34	88	60	99	I5	84	42	7	40	24	48	56	56	24	0
22	26	23	49	2I	53	6	47	45	4	44	20	40	44	48	20	4
23	33	I6	49	I6	85	II	74	4I	6	39	20	40	40	52	20	I2
24	40	I8	58	94	55	7	48	33	8	3I	24	44	72	72	20	0
25	27	30	57	32	92	I7	75	44	6	42	28	44	44	60	I6	I6
26	27	23	50	32	73	II	62	39	5	37	I6	32	52	40	I6	-I2
27	36	28	64	6	92	9	83	4I	9	38	24	40	40	48	I6	8
28	37	I9	56	34	93	I8	75	43	7	4I	20	36	44	48	I6	4
29	38	25	63	42	47	36	II	35	I	34	24	48	40	64	24	24