THE RELATIONSHIP OF SEQUENTIAL PART PRESENTATION OF FORM WITH HIGHER COGNITIVE PROCESSES

A Thesis

Presented to the

Faculty of Graduate Studies and Research

University of Manitoba

In Partial Fulfillment

of the Requirement for the Degree of

Master of Arts

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by

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November, 1967

ACKNOWLEDGEMENTS

The author wishes to express his appreciation to Dr. B. M. Springbett for his encouragement and advice in the preparation of this research.

Appreciation is also extended to Mr. C. L. Bell for his time consuming efforts in the careful construction of the apparatus which made this research possible.

ABSTRACT

The basic purpose of this project is an attempt to relate certain higher cognitive processes to perception or integration of form. It was felt that if parts of a form were presented sequentially, the integration of the sequence in order to attain a percept would relate with performance on such cognitive tests as the DAT-SR, HN-IQ, EFT and RAT, either because of the integration process itself or/and because of common organizational factors inherent in both the forms and cognitive tests.

Three different types of stimuli were utilized; (a) meaningful forms, i.e. cube, (b) verbal forms, i.e. the word NUN, and (c) nonsense forms, i.e. no meaning, no symmetry. Lines of these figures were presented in sequence in a predetermined random order with increasing frequency from trial to trial. The frequency at which the figure was perceived or correctly identified was then correlated with performance on the various ability tests, and significant relationships were found with the DAT-SR, EFT and verbal IQ. For comparative purposes, threshold measures, of the same forms, obtained by means of tachistoscopic presentation were correlated with performance on the cognitive tests. No significant results were obtained using the t-scope data. It was concluded that the relationships found between the perception of form under the condition of sequential part presentation and the cognitive test were due to: (a) the integrative process, inasmuch as the S must retain and integrate a sequence of parts; (b) perceptual learning (in a "Hebbian" sense) as is the case with the nonsense figures and (c) common organizational factors inherent in both the forms and cognitive tests.

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CHAPTER I

INTRODUCTION

The main purpose of this study is to investigate the nature of some of the relationships between higher and lower orders of cognitive processes. The general experimental design closely parallels the one employed by Springbett, Dark and Clake (1957) and Springbett (1957) in their use of the Lines Test to make an exploratory investigation of creative thinking. The basic difference between the present study and the earlier ones is in the task confronting the Ss. In the studies done by Springbett et al., the task presented to the S was one of rote memory while in the present study it is perceptual.

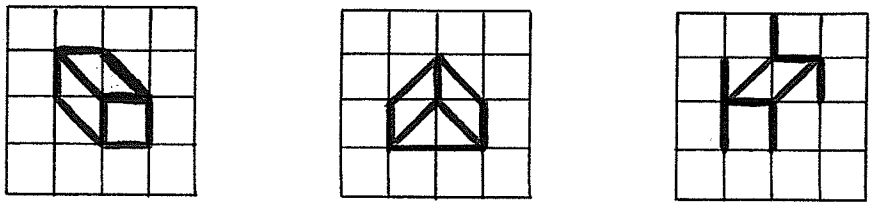
It should be noted that while the earlier studies were prompted by an interest in creative thinking, the factual results demonstrated only that there was a pattern of relationships between the rote memory task in the Lines Test and a series of conventional tests.

Because the rationale of the experimental design is basically the same in both of these approaches (perceptual and rote memory) a brief account of the earlier studies is indicated.

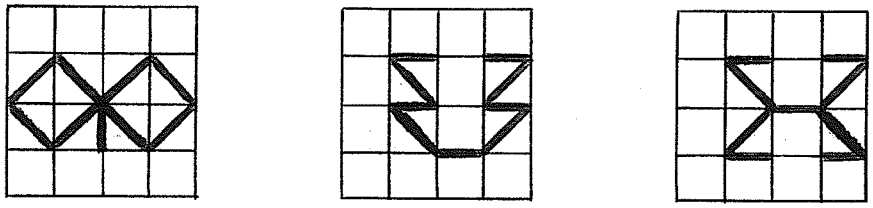
Springbett et al., (1957) constructed three different classes of line figures: meaningful (M - i.e. could be named e.g. box); Gestalt (G - symmetric but unfamiliar); nonsense figures (N - unsymmetrical, no closed parts and not familiar). (See Figure 1).

In the test situation, the S was shown the lines of a figure. The lines were presented one at a time and one every two seconds and each one in the appropriate position on a rectangular grid. After all the lines had been presented, the S was asked to draw all the lines he could remember on a single grid. A score of 1 was given for each line correctly

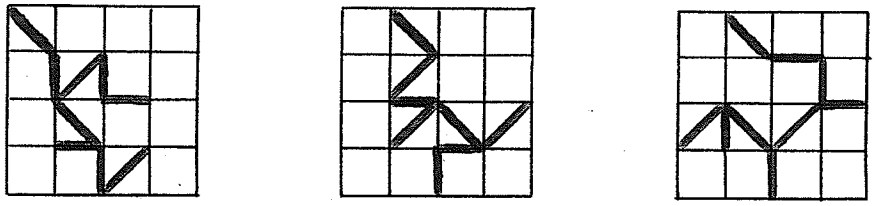
LINES TEST



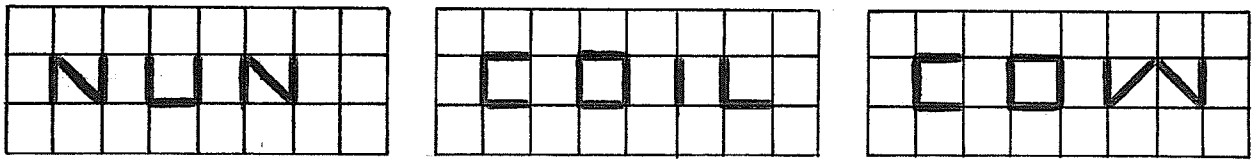
Meaningful Forms



Geometric Forms



Nonsense Forms



Verbal Forms

Figure 1

correctly placed. The scores on the particular figures in a class were then combined to represent the M, G and N scores. The investigators found significant differences in scores between the three classes of figures, with the score for the M figures being the highest and for the N figures the lowest.

The M, G and N scores were then correlated with such tests as the Otis IQ, DAT Spatial Relations Test, Abstract Reasoning Test and the Mooney Closure Test. M figures correlated significantly with all the tests; the G figures with the Otis Test of Mental Ability. The N figures did not correlate significantly with any of the tests.

In a follow up study (Springbett, 1957) a test was designed using words, i.e. verbal forms. (See Figure 1). This form of the Lines Test produced the highest correlations with verbal intelligence - higher than the correlation coefficient between the M figures and verbal intelligence.

Inasmuch as the Ss rarely were able to correctly reproduce all lines and insofar as the instructions to the Ss gave no hint of configuration, it is obvious that they were never aware of the organizations involved in the various forms. Yet since the scores on the M figures are highest and the N figures lowest, and since the relationship between the conventional test and the Lines Test is strongest where the organization in the forms is relevant to the conventional test as in the case of verbal forms and a verbal intelligence and since there was an absence of covariation between the various ability tests and the N figures where no meaningful organization is present, it becomes obvious that there was a utilization of organization involved in the various figures. Thus, the role of organization must act as an unconscious level. Quoting from Springbett et al. (1957):

> "The role of the unconscious organization is viewed as follows: it is assumed that the nine lines of a meaningful figure, separately presented, will partially activate the neural organization normally involved in perceiving such a figure; when the subject attempts to recall these lines they will be better remembered by virtue of their membership in this organization, provided that the subject is not dominated by his conscious processes but is sensitive to those which are unconscious." (p. 14)

One of the unexplored variables is the rate of presentation of the separate elements of the form or figure. When the possibility of testing the limits of the rate of presentation of the lines is considered, it becomes obvious that at a given rate apparent movement (AM) of the lines will emerge and at a still higher rate AM will cease and simultaneity and perception of form will occur. It is the purpose of this study to determine whether (a) the rate of presentation at which form perception occurs will differ with the different classes of figures and (b) whether individual differences at which integration or form perception occurs will be related to the individual differences on cognitive tests measuring abilities relevant to the corresponding structures embodied in the different classes of figures.

In the Lines Test with a rate of presentation of 1 line every 2 seconds rote memory and conceptual integration were necessary for successful performance on test items. In the present study with rapid rates of presentation the integration is of a perceptual character. Inasmuch as this experimental approach involves form perception via sequential part presentation (SPP) and also involves apparent movement (AM), consideration of these topics, as they relate to the thesis problem is indicated.

Form Perception by Way of Sequential Part Presentation

Excepting AM at the moment and considering rates of sequential part presentation (SPP) of form at which perceptual integration occurs, the process of integration may be thought of in terms of some brain model such

as Hebb's (1949). For instance, it may be supposed that each line activates part of a phase sequence or t-assembly or some other centrally located storage mechanism. After activation of the necessary number of these "units" integration occurs, in terms of Hebb's model, the "t-assembly" is activated (Hebb, 1949). The assumption is that SPP of form results in storing the parts centrally with subsequent integration being responsible for the percept (as opposed to retinal storage and retinal integration and subsequent transmission in a holistic sense). Theoretical and experimental developments furthering some type of operation of analysis and integration has come from such authors as Hebb, 1949; Hubel, D.H. and Wiesel, T.M., 1959; Deutsch, 1960; Dodwell, 1962; Sutherland, 1960, to name only some.

The feasibility of the assumption that in form perception parts are stored centrally with consequent integration being responsible for the percept, has been demonstrated by Parks (1965). Parks moved simple figures behind a narrow slit as small as 1/64" over periods of time ranging from 1/4 - 1/2 second. Ss actually saw the figure - at slower speeds they could only identify it. Retinal storage is unlikely since the eye is fixated and a small part of the retina must transmit all information quickly. Parks states:

> ".....components of storage is more central than the receptors and it possesses dynamic properties (the various slices of the figure must be reassembled in terms of some time-of-arrival coding)... Furthermore, the fact that at low speeds O may report the nature of the stimulus without reporting that he has seen it directly as a whole may provide the basis for an operational distinction between visual storage and short term storage proper". (p. 147)

In a different context and with a different purpose than applied to the present study, McFarland (1965) utilized sequential presentation of

lines in one case and angles in another of an equilateral triangle to determine frequency levels for non-joining and non-simultaneity. It was his purpose to develop an experimental method of stimulus presentation in accordance with the theoretical developments which view perception as a process of analysis and integration.

In both McFarland's (1965) and Parks' (1965) studies, a temporal factor is introduced in the perceptual tasks. The temporal factor serves to break up the stimulus into sequential parts. The S must somehow retain the sequence and integrate the same in order to achieve a percept of the stimulus. It is this integrative process of which SPP would be a measure.

This temporal factor as it applies to SPP is not involved in simultaneous presentation or tachistocopic (TP) presentation of form. It is possible, of course, that in the case of TP, form perception occurs as a result of serial coding and resultant integration. A threshold measure utilizing TP would not have a tendency to measure the integrative capacity of the visual system as would be the case in SPP since in the case of TP, the process of serial coding would occur in such a fashion where the temporal storage of serial signals would presumably be at a minimum and optimal for resultant integration or perception of form.

If frequency at which perception of form occurs in SPP is a measure of the integrative capacity of the visual system, it might be related to performance on other cognitive tests. This would stem from the fact that even though integration of sequential events in SPP is on a perceptual level, cognition also involves sequential orders and integration of such orders.

Apparent Motion

If experimental procedure in sequential presentation of lines of a figure is such where the frequency of lines/second is increased until the figure can be identified, the phenomena of apparent motion (AM) must be considered. If AM was simply dependent upon stimulus parameters (i.e. intensity, interstimulus interval, retinal separation, etc.) then one could simply view it as a complicating factor until the appropriate frequency is reached where analyses and integration can occur.

However, studies have shown that AM is related to such factors as meaning (Toch & Ittellson, 1956); directional information (Brown, 1956, Jeeves & Brumer, 1956, Jeeves, 1964); age and IQ (Pollock, 1965, Hamilton, 1960); and neuroticism (Hamilton, 1960).

Toch and Ittleson (1956) found that AM had a tendency to take that direction most in accord with the direction the stimulus would normally take (i.e. bomb falling downwards). Hamilton (1960) found smaller mean movement intervals for neurotics and that these mean movement intervals decreased with age.

Insofar as the task for the Ss is to perceive the stimulus figure at a minimum frequency of sequential presentation, it is possible that in the service of meaning the simultaneity threshold can be lowered. The extent to which AM can be "inhibited" or resolved in this experimental task may thus be related to a variety of higher cognitive processes.

CHAPTER II

METHOD

The most difficult technical problem was to find some means of sequentially presenting the elements of the Lines Test over a wide range of frequencies. The technical details of the apparatus are presented in the Appendix A. The whole conception and production of the apparatus was conducted by Mr. L. Bell (University of Manitoba). It will suffice to say here that each line component was produced by embedding a neon bulb in a clear plastic wedge and masking the wedge so as to have an illuminated slit when the bulb was lit. From an array of such units (for diagram see Appendix A) mounted on a panel, a multi-pole-multi-position switch was used to select the appropriate pattern which could be presented sequentially or simultaneously. Insofar as the apparatus precluded variation in sequence of line presentation of any form, the order within any figure was fixed for all Ss. Rates of line presentation could be varied from 6 lines/second to 115 lines/second. The off-on ratio was set at 1:1 irrespective of frequency. Ultra violet light was utilized to insure regular operation of neon lights.

The forms used are shown in Figure 2. The M figures are the same as those used in the original Lines Test. The type of words chosen was mainly dependent on technical considerations since in its present form all the patterns have to have the same number of line components (9 in each pattern) and all the patterns had to fit into the most economical arrangement possible. The N figures, although somewhat different from the Lines Test were constructed along the same principle, i.e. no enclosed parts, no symmetry, and lacking familiar pattern.

Figure 2

FORMS USED IN PERCEPTUAL TASK

MEANINGFUL FORMS (M)

Fig. 1*

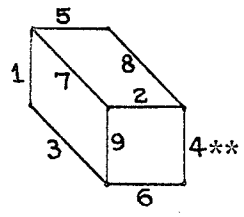


Fig. 2

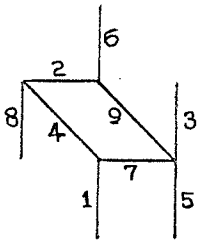
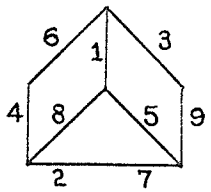


Fig. 3



VERBAL FORMS (V)

Fig. 6

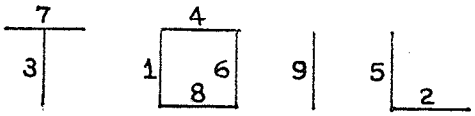


Fig. 5

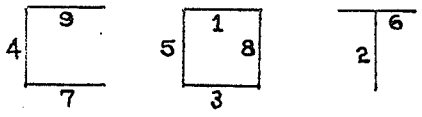
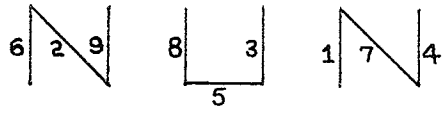


Fig. 4



NONSENSE FORMS (N)

Fig. 7

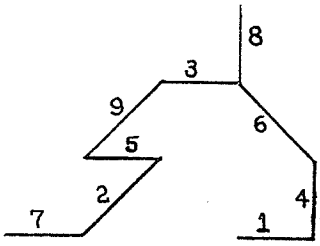


Fig. 8

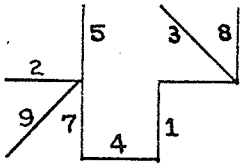
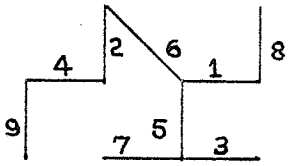


Fig. 9



* Fig. No.'s refer to variables 1 through 9 in complete correlation matrices in Appendix B (pp.).

** Numbers indicate sequence used in sequential part presentation of form.

Testing Materials

The main question being put by the experiment is whether individual differences in the ability to achieve perception of form from sequentially presented elements is associated with ability to manipulate material of a like category at the conceptual level. The Henmon Nelson Tests of Mental Ability, Revised Edition, Form A (HN) was selected as a measure of verbal abilities with the expectation that performance on it would be related to the performance on the V figures. On the basis of the findings on the Lines Test, it was expected that the Differential Aptitude Test of Space Relations, Form A (DAT) would relate with performance on the M and V figures and not with the N figures.

The short form of the Embedded Figures Test (EFT) was included in the battery on an intuitive basis. A M of the lines seemed to mask the elements and it appeared a reasonable analogy to think of the elements being embedded in a nexus of movement.

Form A of the Remote Association was included because the purpose of the Lines Test was to achieve a measure of creative thinking. The integration of the subordinate terms by way of common mediators has some analogy with the integration of elements in the verbal figures.

Subjects

Ninety three Ss - 55 males and 38 females from the Introductory Psychology Class at the University of Manitoba participated in this experiment (a more balanced number was intended but absenteeism and lack of female Ss resulted in present numbers). All Ss participating in this experiment were doing so in partial fulfillment of the course requirement of 5 hours of experimental work.

Procedure

Conventional Tests. All Ss reported for a group testing session. The HN, DAT and RAT were administered in that order. Instructions and procedures for each test followed, the directions accompanying each test. Times were carefully checked by a stopwatch. The tests were scored in accordance with standard procedure. The DAT and HN scores were not changed to percentiles but left in their raw form.

All Ss were tested individually when EFT and perceptual tasks were administered. The EFT was administered according to the standard directions accompanying the test (Witkin, 1954).

Perceptual Tests. The perceptual task was either of a simultaneous or sequential type. Ss were assigned alternately to each condition as they reported for this part of the experiment. In both conditions Ss were seated 5 feet from the apparatus. Insofar as the size of the forms were relatively large (see Appendix A) and insofar as AM in the sequential condition compels eye movement, no effort was made to control either eye movements or head movements.

The following instructions were given to Ss in the sequential condition:

> "In front of you, you see a piece of equipment which is capable of presenting lines of light one at a time and one after the other at a rapid rate. The lines of light during any presentation will form some type of line figure or form. You will be given 10 second trials during which the lines of light will go on and off sequentially and your job is to identify the form or figure by letting me know when you can see it. Once you see it, you can either name or draw it. Some forms you will not be able to name insofar as they form a collection of lines with little symmetry and no meaning. You may start drawing the form anytime you like, but once you start drawing you may not refer back to the apparatus until you are finished drawing. The 10 second trial will be repeated until you correctly name or draw the form being presented. You will find during the first few trials on a particular form you will have

difficulty in identifying the figure because of a condition known as apparent movement. You will find the lines appear to jump around or move from one spot to another just as is the case in neon signs or movies. As we continue from trial to trial you will see this will disappear and a stable form emerge. As soon as this happens please name or draw the figure. There will be several forms to do. Are there any questions?"

The following instructions were given to Ss in the t-scope condition:

"In front of you we have a piece of equipment which is capable of presenting line forms or figures for very short durations. Your job is to identify the figure shown during such an interval by either naming or drawing it. Some forms you will not be able to name as they will form a collection of lines with little symmetry and no meaning. If you cannot correctly identify it on the first trial we will try it again until you correctly identify it. There will be several forms to do. Are there any questions?"

In both conditions, forms were then presented in random order with the added restriction that no two forms from a particular class, i.e. verbal, meaningful and nonsense, would be presented consecutively.

The ultra violet light had an interesting side effect as some forms of white paper "light up" under this light without adding much to the general illumination of the room. Thus, both Ss and E could easily see what was being drawn with a minimum of experimental procedure.

In the sequential procedure the first trial of 10 second duration started with a frequency of 8 c/s. The frequency of each subsequent trial was increased by 4 c/s until S could either name or draw the figure. The frequency at which proper identification occurred was then recorded.

In the simultaneous condition duration of the first trial was 1 m.s. Subsequent trials were increased by 1 m.s. The duration at which proper identification occurred was then recorded.

CHAPTER III

RESULTS

For the perceptual measures 4 other scores were set up. Variables 10, 11 and 12 represent the summation of the scores on the M, V and N figures respectively. Variable 13 represents the sum of all 9 perceptual scores. For the cognitive variables IQ was broken down into numerical (14), verbal (15) and total (16) and were left in raw form as were the EFT scores. Varibales 17, 18 and 19 represent EFT, DAT-SR and RAT respectively. Data for variables 1 through 19 is listed in Appendix C.

Significant differences between M, V and N scores (variables 10, 11 and 12) were found in both the SPP and T conditions where $F = 9.65$; $df = 2,106$; $p < .05$ and $F = 85.56$; $df = 2,72$; $p < .05$ respectively. (See Tables 1 and 2 for analysis of variance - unweighted means solution) (Weiner, 1962). The same analysis also indicates no significant differences between males and females in both SPP and T conditions ($F = 1.09$; $df = 1,53$; $p > .05$ and $F < 1$ respectively) for performance on the M, V and N perceptual tasks.

Insofar as there was reason to suspect significant differences between males and females, at least on such measures as the EFT and the DAT-SR, both the SPP and T conditions were divided into two groups representing males and females. Complete correlation matrices were calculated for all four groups (See Appendix B). The relevant subsets of correlation coefficients are listed in Tables 3 through 6. Significance of correlation coefficients was determined by using a one-tailed t-test with confidence level set at $p < .05$. All significant coefficients are asterixed in Tables 3 through 6. As can be seen both the EFT and DAT-SR

correlate well with perceptual variables in SPP-male group (Table 3). Moreover in this group verbal IQ correlates significantly with verbal figures. None of the coefficients for the SPP-female group (Table 4) are significant.

For T condition-males (Table 5) a different pattern emerges. The DAT-SR correlates well with the perceptual scores but the EFT correlates significantly with the nonsense figures in the opposite to expected direction. Again, as in the SPP condition there are no significant correlations for the female group (Table 6).

In testing for differences in covariation between males and females (2 tailed t, $p > .05$), no significant differences could be found except for coefficients 18, 11 and 18, 13 which differed significantly in both SPP and T conditions. Except for the fact that coefficients 18, 11 and 18, 13 are highly dependent on each other (not only is variable 18 common to both but 11 is common to 13 since variable 13 is the sum of all perceptual scores), it is difficult to evaluate the meaning of these two significant differences. However, on the assumption that there is a high probability that by chance alone the odd significant difference of this kind can occur, there does not appear to be a difference in covariance between males and females. In addition to this, it was also found that males and females in both the SPP and T groups did not differ significantly on the EFT ($t = .436$; $N = 55$; $p > .05$ and $t = .713$; $N = 38$; $p > .05$ respectively) and the DAT-SR ($t = .179$; $N = 55$; $p > .05$ and $t = .370$; $N = 38$; $p > .05$ respectively).

In view of the lack of sex differences as discussed above, it was considered justifiable to combine males and females for each condition.

A complete correlation matrix for both the SPP and T group were calculated(Appendix B). The relevant subsets of correlation coefficients are listed in Tables 7 and 8. All correlation coefficients with EFT and DAT-SR are significant in SPP condition (Table 7). Also verbal IQ correlates significantly with V figures. None of the coefficients for the T condition except for 1 (RAT and N figures) are significant.

TABLE 1

ANALYSIS OF VARIANCE ON PERCEPTUAL SCORES
FOR THE SPP CONDITION - UNWEIGHTED MEANS SOLUTION

Sources of Variation	SS	df	MS	F
Between Ss		54		
A	1,631.7	1	1,631.7	1.09
Ss w. groups	791,209.6	53	1,492.8	
Within Ss		110		
B	42,855.0	2	21,427.5	9.65*
AB	1,870,288.8	2	935,144.4	421.52*
B x Ss w. groups	235,166.0	106	2,218.5	

*$p < .05$

TABLE 2

ANALYSIS OF VARIANCE ON PERCEPTUAL SCORES
FOR THE T CONDITION - UNWEIGHTED MEANS SOLUTION

Sources of Variation	SS	df	MS	F
Between Ss		37		
A	19.81	1	19.81	
Ss w. groups	4,732.95	36	131.47	
Within Ss		76		
B	5,003.77	2	2,501.88	85.56*
AB	3.81	2	1.91	
B x Ss w. groups	2,105.05	72	29.24	

*$p < .05$

TABLE 3

CORRELATION COEFFICIENTS BETWEEN PERCEPTUAL AND COGNITIVE VARIABLES

Sequential Part Presentation - Males

Cognitive Variables		Perceptual Variables: Meaningful	Verbal	Nonsense	Total (M+V+N)
		10[a]	11	12	13
Quantitative IQ	-14[a]	-.093	-.253	-.309	-.265
Verbal IQ	-15	-.197	-.414*	-.308	-.354*
IQ (Q+V)	-16	-.172	-.394*	-.360*	-.364*
EFT	-17	.360*	.462*	.420*	.474*
DAT-SR	-18	-.440*	-.641*	-.746*	-.718*
RAT	-19	.055	-.130	-.115	-.084

* t > 1.708, N=27, p < .05

TABLE 4

CORRELATION COEFFICIENTS BETWEEN PERCEPTUAL AND COGNITIVE VARIABLES

Sequential Part Presentation - Females

Cognitive Variables		Perceptual Variables: Meaningful	Verbal	Nonsense	Total (M+V+N)
		10[a]	11	12	13
Quantitative IQ	-14[a]	.036	.065	-.233	-.060
Verbal IQ	-15	.119	-.265	-.016	-.079
IQ (Q+V)	-16	.111	-.190	-.105	-.088
EFT	-17	.099	-.082	.043	.031
DAT-SR	-18	-.263	-.019	-.349	-.251
RAT	-19	-.179	-.022	-.025	-.073

* t > 1.746, N=28, p < .05

NOTE: For complete correlation matrix see Appendix B. a - numbers refer to numbers in text and complete matrix in Appendix.