LAKEHEAD UNIVERSITY

CLOSURE AS IT RELATES TO PERCEPTION AND THINKING

by

© JOSEPH N. AGOSTINO

A THESIS

SUBMITTED TO THE FACULTY OF ARTS

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR

THE DEGREE OF MASTER OF ARTS

DEPARTMENT OF PSYCHOLOGY

THUNDER BAY, ONTARIO, CANADA

MAY 1980

LICENSING AGREEMENT

THIS AGREEMENT, entered into as of December 29, 1978, between Educational Testing Service (hereinafter called "ETS"), a nonstock, nonprofit corporation organized and existing under the Education Law of the State of New York, with offices at Princeton, New Jersey 08541, and

Joseph N. Agostino
Department of Psychology
Lakehead University
Oliver Road
Thunder Bay, Ontario, Canada P7B 5E1

(hereinafter called "Licensee"),

WITNESSETH:

WHEREAS, ETS is the publisher and copyright owner of certain test materials; and

WHEREAS, Licensee wishes to produce editions of:

Gestalt Completion Test	- CS-1
Concealed Words Test	- CS-2
Snowy Pictures	- CS-3
Letter Sets Test	- I-1 (Rev.)
Locations Test	- I-2
Figure Classification	- I-3

NOW, THEREFORE, ETS, agrees that Licensee may reproduce and distribute up to 100 copies each of the above editions for use in a Master's thesis study at Lakehead University, subject to the following terms and conditions:

1. Each copy of any edition produced under the Agreement shall bear a copyright notice exactly as it appears on the original test, followed by the statement: Reproduced under license.

2. Licensee agrees to pay ETS a licensing fee of $60.00 (U. S. dollars). Payment shall be sent to Educational Testing Service, to the attention of:

   Russell W. Martin, Jr.
   Assistant General Counsel

   Licensee will be responsible for any costs involved in the composition, reproduction, and distribution of the editions licensed herein.

3. Test copies or items are not to be included in research reports or other publications resulting from this use.

Acknowledgements

I would like to thank the members of my thesis committee, Dr. Irving A. Taylor and Dr. Norman Ginsburg for their invaluable assistance and guidance throughout the development of the thesis. Their patience and genuine concern have been instrumental in providing an opportunity for academic achievement and creative expression.

My sincere appreciation to the Department of Psychology for their cooperation in providing the facilities and subjects for this research.

Special thanks to Ginnie Taylor, inter-library loan librarian, for her dedicated effort in fulfilling my numerous requests for journal articles, manuscripts, microfilms and the like. Her assistance was gratefully appreciated.

I would also like to thank the Otis Elevator Company for their cooperation in providing parts, diagrams, and technical assistance for the construction and operation of the Otis Elevator Touch Button. Thanks also to Gord Coates for putting it all together.

Lastly, I would like to thank my parents for their encouragement and support.

To My Daughters

SUSAN and CAROLYN

Abstract

The purpose of the present study was to explore the relation between inductive closure and perceptual closure. Specifically, the study investigated (a) whether closure phenomena, primarily investigated in perception, could be found to occur in thinking and (b), whether functional properties underlying structured wholes in perception (tendency to closure) possess the same or similar functional properties in thinking. Inductive reasoning tests were selected to demonstrate closure phenomena in thinking and speed of closure tests were selected to demonstrate closure phenomena in perception. An inductive reasoning test consisting of a visual and motor component (visual motor task) was designed to demonstrate structural dynamics underlying closure phenomena in thinking. Subjects were instructed to tap on a response button (motor component) as a means of testing hypotheses that would fit the visual data. Closure was achieved through the reduction of hypotheses that failed to outline or define the relationship demanded by the data. A random sampling of 80 male/female students enrolled in a first year introductory course at Lakehead University was necessary to obtain a final sample of 20 students for each of three closure groups. Subjects scoring in the upper, middle, and lower quartiles on the

speed of closure tests were designated as high, moderate, and low speed of closure groups respectively. Data from the inductive reasoning tests and the visual motor task tended to support the two general hypotheses. The results indicated (a) a significant relationship between perceptual closure as manifest on speed of closure tests and inductive closure as manifest on inductive reasoning tests, and (b) a significant relationship between perceptual closure as manifest on speed of closure tests and inductive closure as manifest on the visual motor task. In order to provide a richer understanding of the closure/reasoning relationship, consideration must also be given to other forms of thinking (abduction, deduction) and performance in problem solving situations.

Table of Contents

Page

List of Tables

List of Figures

Statement of the Problem

Gestalt psychology maintained that we see our world as an organized unity. For example, the world that we experience is stable, well-defined, regular, simplistic, etc. Wertheimer (1923/1938) formulated a number of principles to account for organizational processes. These principles were initially investigated in perception and later extended to include all psychological phenomena - learning, thinking, emotions, personality, etc.

The present research focussed on the principle of closure. The closure principle was initially formulated to describe completion phenomena in perception. In 1942, Bobbitt extended the term to include all psychological phenomena. He defined closure as "any psychological phenomenon in which a condition of incompleteness, either in the stimulus field or in some phase of the organism's [cognitive or behavioural] activities, creates a tendency to overcome this incompleteness by perceptual [or cognitive] organization, by a combination of two or more different experiences, or by some overt activity of the organism" (p. 274).

In order to study the relation between closure in perception and thinking, individuals were compared with regard to their performance on perceptual closure tests and problem solving tests (not directly related to the perceptual task). Closure as understood in perception accounted for the phenomenal completion of perceptually incomplete stimuli; closure as understood in thinking accounted for the solution in problem solving tasks. A problem solving situation was considered an open situation that called for closure.

In the present study, inductive reasoning was selected for the study of closure in thinking. Inductive reasoning problems required that an individual discover a rule or principle that described the relationship demanded by the data. Closure was achieved through the reduction of hypotheses that failed to define the relationship demanded by the data (inductive closure).

Thurstone (1949) reported that perceptual closure might be associated with inductive reasoning; Pemberton (1952) however, failed to obtain conclusive evidence for the generalization of perceptual closure to the higher cognitive processes. In a recent literature review, Wardell and Royce (1975) investigated the relationship between perceptual closure and inductive reasoning. Their results tended to support the closure/reasoning relationship.

The present study also investigated whether functional properties underlying structured wholes in perception (tendency to closure) possess the same or similar functional properties in thinking.

Harrower (1932) used the joke as a non-perceptual structured whole to demonstrate complementary relationships in perception and thinking. "It seemed as if the joke allowed some sort of diagrammatic representation of the particular relations holding within its parts: directly analogous to the difference in form and structure in the field of perception" (p. 58). The form/structure relationship described by Koffka (1935) was considered to be inherent in all problem solving situations:

> The whole process stays, as it were, inside the boundaries set by the data of the problem. If the solution is found, intrinsic relations must have acted as dynamic relations . . . . the dynamics of the process are determined by the intrinsic properties of the data. (p. 631)

An inductive reasoning task consisting of a visual and motor component (visual motor task) was designed to provide a diagrammatic representation of the structural dynamics underlying closure phenomena in a problem solving situation. The visual motor task (VMT) utilized an event recorder to record the subject's tapping-response behaviour. Subjects were instructed to tap on a response button as a means of testing hypotheses that would fit the visual data. Closure as manifest by an increased rate of responding across stages was achieved by a reduction of hypotheses that failed to produce the intended solution. Frederiksen (1965) found that individuals who were high in speed of closure produced many initial hypotheses when presented with ambiguous visual stimuli. These individuals demonstrated earlier recognition of the visual stimuli than individuals producing fewer hypotheses. These results suggested that the high closure group was more effective at formulating and testing hypotheses than either the moderate or low closure group.

Hypotheses

Two general hypotheses were formulated to facilitate they study of perceptual closure and inductive closure.

General Hypothesis I

Closure phenomena, primarily investigated in perception, can be found to occur in thinking. This general hypothesis was further divided into the following specific hypotheses:

1. There will be a significant overall positive correlation between perceptual closure as manifest on speed of closure tests and inductive closure as manifest on inductive reasoning tests.

2. There will be significant positive correlations between

individual tests that define the perceptual closure factor (Gestalt Completion Test, Concealed Words Test, Snowy Pictures Test) and the individual tests that define the inductive closure factor (Letter Sets Test, Locations Test, Figure Classification Test).

Subjects will be divided into high, moderate, and low perceptual closure groups and compared with regard to their performance on the inductive reasoning tests.

3. There will be significant positive correlations between perceptual closure as manifest on speed of closure tests and inductive closure as manifest on inductive reasoning tests for the high, moderate, and low closure groups.

4. There will be a significant difference between the performance of high, moderate, and low closure groups on the inductive reasoning tests.

General Hypothesis II

Functional properties underlying structured wholes in perception (tendency to closure) possess the same or similar functional properties in thinking. This general hypothesis was further divided into the following specific hypotheses.

5. There will be a significant difference in the mean response rate for the high, moderate, and low closure groups on the VMT. The high closure group will manifest the

highest mean response rate, followed by the moderate and low closure group.

6. The high closure group will be more effective at problem solving on the VMT than either the moderate or low closure group by demonstrating a tendency to systematically increase responding across stages. A significant linear trend in responding across stages for the high closure group will be produced.

Review of the Literature

Organizational processes in perception and thinking

Gestalt psychologists maintained that all psychological phenomena were understood in terms of organized wholes, as opposed to the piecemeal, and - summation, atomistic approach of the structuralist and behaviourist schools. Wertheimer, in his article Laws of Organization in Perceptual Forms, outlined the nature of our perceptual experience as governed by organizational processes:

> When we are presented with a number of stimuli we do not as a rule experience "a number" of individual things, this one and that and that. Instead larger wholes separated from and related to one another are given in experience; their arrangement and division are concrete and definite. (1923/1938,[1] p. 72)

He elaborated on the terms "arrangement and division" by formulating a number of principles to account for perceptual organization. These basic principles included: closure, proximity, similarity, uniform destiny (common fate), objective set (Einstellung), direction, good curve, etc.

Complex ego functions or 'so called' mental processes could not provide adequate explanations to account for organizational processes - since we are unaware of how stimuli influence each other at the moment of their occurrence; nor could they be explained as innate phenomena. Organizational processes were determined by the intrinsic nature of 'what we saw'.

Wertheimer (1959) in his study of complex reasoning processes in humans, extended the laws of organization underlying perceptual gestalt to include productive thinking. Dynamic organization in perception and thinking was founded on the principle of psychophysical isomorphism (Köhler, 1920/1938). Isomorphism, a cortical-field theory, signified a topological correspondence between organizational processes in perception and thinking, and neurophysiological processes of organization in the brain. Bolton (1972) stated that "it is the assumed structural identity of these two processes which makes possible a physical-physiological explanation of psychological organization" (p. 22).

Koffka (1935) believed that the similarity between organizational processes in perception and thinking were closer than generally considered. Organizational principles had been outlined by Wertheimer (1923/1938) to account for 'how we see'. These principles described intrinsic properties of psychophysical processes in perception. Koffka (1935) suggested that our goal was to find intrinsic properties of psychophysical processes in thought to account for 'how we think'. He outlined the advantages and disadvantages that must be considered in the investigation of intrinsic psychophysical processes in perception and thinking:

> The perceptual problem keeps us closer to the actual physiological events than the thought problem where physiological hypotheses are speculative to a much greater degree even than in the field of perception. On the other hand, the "purer" thought processes are, the more they will reveal the efficacy of properties which are apt to be obscured in perception because of the contingent stimulus distribution. (Koffka, 1935, p. 632)

He suggested that problems concerning organizational processes in perception and thinking may have to be investigated at "different levels". Solutions to problems involved in the study of perception must be given paralleled consideration in the study of thinking. He further stated that "answers which must satisfy our curiosity on the level of thought will have to be much more concrete on the level of perception" (p. 632). This cautionary note, however, implied that this difference "is a difference in our knowledge of things and not a difference in the things themselves" (p. 632).

Perceptual closure

Closure phenomena had been investigated in various areas such as poetry (Smith, 1968), music (Meyer, 1956), and sports (Hartgenbusch, 1926/1927). The interest that this gestalt principle generated suggested that it was neither restricted nor limited in its expression. Closure as a multifaceted concept had been studied in many areas of psychology which included personality (Angyal, 1948), aesthetics (Hubbell, 1940), problem solving in apes (Köhler, 1925/1927), social attitudes (I. A. Taylor, 1960), problem solving in humans (Wertheimer, 1959) etc. Thurstone (1944) in an extensive factor analytic study of perception, isolated several factors in perceptual dynamics. Thurstone's investigation of closure phenomena was directed towards facility in perceptual closure as opposed to considerations of perceptual acuity.

Early demonstrations of completion phenomenon--tendency to closure--were introduced by Jastrow (1901). He presented letters with incomplete contours (see Appendix G) which tended to be perceived as complete. He stated that subjects reproducing these letters tended to complete the contours of the letters with light lines "which in the original are suggested but not really present" (p. 280). Koffka (1922) described completion phenomena in terms of a 'closed' figure. He explained that "phenomenal figures have boundary lines even when the corresponding objective figures have none. A good figure is always a 'closed' figure, which the boundary line has the function of closing" (p. 557). Koffka (1935) operationally defined the boundary line phenomenon as a "closure of good continuation".

> If the unit is "open" or "incomplete" then that part of the field which corresponds to the gap will be a seat of very particular forces, forces which will make the arousal of processes of closure easier than the arousal of any others. The closure will, of course, be that closure which is demanded by the rest of the figure, a closure of good continuation. (p. 449)

For many researchers (for example: Bakay & Schiller, 1948; Hubbell, 1940; Roseman, 1952-53; Schiller & Hartmann, 1951) figure manipulation, which involved "open" or "incomplete" parts, provided the tools necessary for the investigation of completion phenomena. Subjects preferred arrangements or designs that were more satisfying. Their efforts tended to demonstrate a tendency towards better or more adequate "additions" to existing structured forms--a tendency towards the "good" gestalt. Wertheimer stated that the completion of incomplete phenomena cannot be attributed to "mechanized habit", but were determined in the situation by concrete gestalt laws: "Thus the completion of an incomplete experience is effected not by the bare addition of just any, arbitrary datum, but through the operation of whole-factors and concrete Gestalt laws" (1922/1938, p. 16). Wertheimer also made reference to the completion tendency (direction of completion) as well as the quality of the completed addition:

> Additions to an incomplete object (e.g. the segment of a curve) may proceed in a direction opposed to that of the original, or they may carry on the principle "logically demanded" by the original . . . . the addition must be viewed also in terms of such characteristic "whole properties" as closure, equilibrium, and symmetry. (1923/1938, p. 83)

The term "symmetry" as referred to by Wertheimer was interpreted to indicate the "logical correctness of a part considered relative to the whole in which that part occurs" (p. 83n).

Techniques which had been used to demonstrate closure phenomena (completion) include (a) the reproduction of open line figures (e.g., B. Taylor, 1952; I. A. Taylor, 1960) and (b), gapped circle patterns (e.g., Holmes, 1968; Richards, 1975; cf. Fuchs, 1921/1938).

Snyder, Rosenthal, and I. A. Taylor (1961) used open line figures--forms containing gaps--to determine the extent to which closure occurs among schizophrenic and normal subjects. Results indicated that schizophrenic subjects failed to produce closure (closure deficit). Snyder et. al. (1961) stated that "the failure to obtain closure may be a function of how schizophrenic subjects deal with and are guided by concepts even when they can form them or have them provided" (p. 136).

In a study of closure and extreme social attitudes, I. A. Taylor (1960) compared "the perceptual reactions of individuals holding opposed social attitudes with regard to closure or completion tendencies manifested in their reproductions of relatively neutral material not directly related in any apparent manner to social issues" (p. 1). Snyder et al. (1961) skillfully summarized the essence of this research. "All subjects tended toward partial completion of incomplete figures; extreme scorers on a social attitude scale tended to close gaps in figures to a greater extent than those who were not extreme in their views, supporting the hypothesis that extreme liberals and extreme conservatives have similar personality characteristics" (p. 131).

Beverly Taylor (1952) attempted to "systematically relate closure to perception, cognition, and emotions as an underlying personality process" (p. 35). In her thesis

An Investigation of Generalized Closure in Personality, she demonstrated that closure, which had been investigated primarily in perception could be studied in cognition. Cognitive closure was measured by the California Fascism Scale (F scale). A strong closure score (high F score) indicated a tendency to agree with overgeneralized statements which did not provide a logical basis for agreement. For example, Item 29: "Nobody ever learned anything really important except through suffering".

Jastrow (1901) presented blotched stimulus patterns obtained from enlarged reproductions of process prints (see Appendix H). Initially, these patterns were considered irregular and meaningless; viewed from a distance, however, they represented familiar figures. Street (1931) constructed picture puzzles (Gestalt completion test) based on a similar principle. This test, which consisted of thirteen items, required the identification of incomplete perceptual forms. "By deletion, parts of each picture have been made to form the ground, so that in order to perceive the picture, it is necessary to complete the structure; that is, to bring about a 'closure' which causes the figure to emerge from the ground" (p. 4). He demonstrated variability in perceptual closure by recording the time taken for individuals to "complete" the structure of the incomplete figures. Street (1931) stated that "one of the distinctive features of the [Gestalt completion] test is that the figure in each item appears only in part; one of the requirements placed upon a subject is that in order to perceive the figure in its entirety, he supply, in his own mind at least, the missing parts" (p. 12).

Closure, as manifest in the phenomenal completion of figure-ground structures (Leeper, 1935; Mooney & Ferguson, 1951; Street, 1931; Verville & Cameron, 1946), were selected as the format for the study of closure tendencies in perception.

Closure in thinking (problem solving)

Bartlett (1951) introduced closure in thinking as filling a gap. He stated that, "it is at least convenient to treat thinking as a special way or ways of filling up gaps or intervals in evidence obtained directly or indirectly from observation" (p. 38). Reiser (1931) argued that "logical processes of reasoning whereby we solve problems (through the use of 'insight') exhibits a 'closure' similar to that of an instinct, and that logical necessity in inference may be analogous to the 'snapping into form' which the gestalters claim is evident in perceptual processes" (p. 360).

Asch (1968) considered that completion tendencies in thinking were analogous to completion tendencies in perceptual forms. His description of thinking implied a parallel with perceptual phenomena. He stated that "under the stress of the initially incomplete view the material is reorganized; parts and relations previously unnoted or in the background emerge, often abruptly, . . . and parts previously separated become united [similar to the 'snapping into form' of figures in picture completion tests]. These changes in the meaning of parts, including changes of relation and direction, produce the transition to a new view that has greater coherence" (p. 163).

Helson (1926) also related closure phenomena and thinking:

> Questions demanding thought arouse configurational processes which are incomplete and call for closure . . . . once the form suggested by the question is apprehended, there is a sudden *Einschnappen*; the inner bond appears, baring the structure, and the configuration is completed. (p. 54)

Koffka (1935) stated that the *kind* of intrinsic properties to be explored in problem solving situations (tendency to closure) may be analogous to those discovered in perception. He cited the example of a gapped circle pattern: "Just as a perceived circle will, as a psychophysical process, 'tend' towards completion, so will [the algebraic problem] x^2+ax, once it is seen as an incomplete square, tend to be completed" (pp. 631-632). Reiser (1931) considered that "a 'problem' presents itself as an open gestalt, which 'yearns' for solution, and it is the function of thought to find the solution by transforming the open gestalt into a closed one" (p. 361).

Hypotheses testing in problem solving situations

Many researchers have implemented the use of investigative tools such as puzzles, mazes, and other manipulative paraphernalia in an effort to study hypotheses testing in problem solving situations. Ruger (1910) used tridimensional puzzles made of wire. The solution to these puzzles required that the individual remove some part from the configuration. In this way, success in testing hypotheses in a problem solving situation could be inferred from the manipulations and overt movements required for the problem's solution. Mather & Kline (1922) explored the means by which individuals discovered and applied rules or principles required for the solution of problems. Their methodology required the use of a series of related problems of increasing difficulty. The investigation of hypotheses testing in problem solving situations was also enhanced by the research efforts of Duncker (1926) and Maier (1930; 1931). Maier had subjects manipulate physical objects, (a) such that a specific combination resulted in a correct solution (1930) and (b), such that each problem had several correct solutions ranging from easy to difficult (1931). Duncker (1926) had subjects report what they believed to be possible solutions to the problems they were presented.

Davison (1964) studied protocols of subjects who were asked to verbalize their thoughts while attempting to recognize ambiguous pictures. The purpose of the study was to identify recurrent trends of thought (or strategies) that were used in an attempt to determine the problem's solution. However, with such a procedure, it was difficult to verify the interpretation of the protocols.

The concept of hypothesis testing in a problem solving situation was undertaken by Johnson (1959). The purpose of the study was to determine the factors which affected the kinds of selection and interpretation of features illustrated in radiographs by medical students. These factors ranged from features of the immediate situation to general expectations of the subject. She stated that "students did not clearly differentiate between a descriptive statement (that can be confirmed by reference to the stimulus pattern alone) and an inferential statement (that cannot be so confirmed because it involves other information), and often made incorrect inferences because they did not recognize the need to test them" (Johnson, 1959, pp. 326-327). She concluded that the "usefulness of deliberately considering and testing alternative hypotheses (thinking) therefore became clear as a method of increasing accuracy and comprehensiveness of seeing" (p. 327).

Bruner (1961) described an experiment which involved a two-choice tapping response apparatus. Although the payoff sequence was arranged at random, one key would have a higher payoff rate than the other (e.g., right 70: left 30). He demonstrated that the behaviour of subjects who adopted an "event-matching" strategy (efforts were directed towards discovering the underlying rule), contrasted with those who adopted a chance or random strategy (efforts were directed towards the higher payoff event). Bruner stated that event-matchers "are trying out hypotheses one after the other, all of them containing a term such that they distribute bets on the two sides with a frequency to match the actual occurrence of events" (p. 24). If successful, their payoff would be 100%.

Inductive reasoning

Inductive philosophy provided the impetus for the exploration of the closure/inductive reasoning controversy. Inductive philosophy was concerned with determining whether there was any support for what was called "the uniformity of nature". According to Russell (1959), the "belief in the uniformity of nature is the belief that everything that has happened or will happen is an instance of some general law to which there are no exceptions" (p. 63). Although nature seemingly presented us with laws subject to exceptions, it was the task of science to replace laws with exceptions, by laws which have no exceptions. This hypothesis can be illustrated by the following example taken from Russell (1959):

> 'Unsupported bodies in air fall' is a general rule to which balloons and aeroplanes are exceptions. But the laws of motion and the law of gravitation, which account for the fact that most bodies fall, also account for the fact that balloons and aeroplanes can rise; thus the laws of motion and the law of gravitation are not subject to these exceptions. (p. 64)

In conclusion, inductive philosophy maintained that "all our conduct is based upon associations which have worked in the past, and which we therefore regard as likely to work in the future; and this likelihood is dependent for its validity upon the inductive principle" (Russell, 1959, p. 69).

Helmholtz (1894/1968) in his essay The Origin of the Correct Interpretation of Our Sensory Impressions, outlined the broad applications of the inductive principle from the viewpoint of an empiricist. These applications included areas of perception, speech, language and motor activity. His applications also extended to developmental processes in children and animals.

The gestalt approach provided a sharp contrast to the empiricist position of Helmholtz. Gestalt psychologists proposed that connections between concrete empirical events "are often related in ways that are structurally simple and that these relations facilitate the learning of the causal interplay" (Asch, 1968, p. 163). Asch further maintained that because underlying functional relations between empirical events were not known directly, conclusions concerning them were based on inductive reasoning. "These relations [referring to those inherent in inductive reasoning processes] make possible a systematic ordering of empirical facts, although the relations are not fully intelligible" (Asch, 1968, p. 163).

Support for the gestalt interpretation was also provided by Wertheimer. He stated that although inductive reasoning type problems were "lacking structural characteristics as to content and connection, [they were not] altogether bare of structural factors. Even if connections are merely factual, merely factually constant, and not understandable, the hierarchy of such connections still offers possibilities either of structurally sensible or structurally blind proceeding" (1959, p. 248).

Structure in thinking

Helson (1926) hypothesized that perception provided the necessary components for thinking: "for thought to proceed along logical lines, it must proceed within a structure, and this structure is very often furnished in perception. The relations of objects to one another are given in phenomenal configurations won in perception" (p. 54). Helson implied that structured processes in perception furnished the means for structured material in thinking, and that these structures may also be responsible for determining the direction of thinking: "A change in the object of perception may mean a change in the whole course of thinking, since rational insight demands the perception of the structure of the whole" (p. 54).

Harrower (1932) used the term "structure" to denote products or results of the organizing process whether in perception or thinking. She demonstrated that non-perceptual material such as the joke allowed some sort of schematic representation of its internal relationships (structure). Joke diagrams provided the necessary material for experimental analysis.

Wertheimer (1959) in his investigation of human problem solving stated that the solution to a problem appeared as a good structure. The term thinking (problem solving), as initially formulated by Wertheimer referred to the "process of reorganization which follows from the tension created by the organism's perception of a problem. When a problem is perceived, structural strains and stresses are established which, if thinking continues, yield vectors in the direction of improvement. The solution of the problem represents a 'good structure', one in which there is harmony between the parts of the field" (Bolton, 1972, pp. 22-23). Piaget (1961/1969) in considering the relationship between perception and intelligence stated that "Gestalt theory considered the act of intelligence to consist in the restructuring of a given situation in the direction of a 'better' form, the forms of intelligence obeying the same laws as those of perception" (p. xxiv).

Structural dynamics underlying the visual motor task

In the present study, the VMT was designed to demonstrate the structural dynamics underlying inductive closure tendencies in thinking. The VMT consisted of two visual components (a television monitor and a momentary light signal), and a motor component (tapping on a response button). The subject was instructed to tap on the response button as a means of testing hypotheses that would fit the visual data. In this problem solving situation, the subject was required to determine (a) whether tapping on the response button was directly responsible for the momentary onset of the light signal or (b), whether tapping on the response button in conjunction with the presentation of stimulus items on the television monitor was responsible for the momentary onset of the light signal. Reducing the number of hypotheses that failed to outline the relationship inherent in the problem solving task, was a function of closure.

The tapping response procedure provided maximum flexibility in formulating and testing hypotheses because instructions concerning the subject's tapping behaviour were too vague to provide direct guidance to the problem's solution. The subject must select an alternative, then formulate and test hypotheses in order to determine which alternative was corrrect. Since the solution possessed an intrinsic relation to the data given in the problem, the answers formulated by the subject occurred as a result of specific properties inherent in the problem situation.

A record of tapping responses provided information concerning the subject's efforts in testing hypotheses. These response patterns (performance record) provided the necessary data for statistical analysis. Each response pattern was assessed in terms of response rate (dependent measure).

The VMT designed for the present study satisfied the following requirements in order to accommodate an in-depth analysis of inductive closure tendencies in a problem solving situation:

(a) As an inductive reasoning task. The VMT required the individual to formulate and test hypotheses in an effort to determine the correct solution to the problem.

(b) As a structured whole. Harrower (1932) in relating to organizational processes in perception stated that wholes have a "definite external form, and an internal structure" (p. 57). Similarly, structured wholes underlying inductive reasoning processes in the visual motor task met the criteria of an external form ("boundary lines") and an internal structure ("relations within its parts"): the former represented by a preselected number of responses (specified limit), the latter represented by the time taken to produce these responses (unspecified limit).

(c) As a diagrammatic expression of its inner dynamics. A record of response/non-response events was provided by tapping on the response button. These events represented various hypotheses tested in an attempt to obtain a solution.

(d) As a demonstration of inductive closure phenomena. Closure was achieved through the reduction of hypotheses that failed to outline or define the relationship demanded by the data.

Method

Subjects

A final sample of 40 male and 40 female students enrolled in a first year introductory psychology course at Lakehead University participated in the study (median age, 19.75 years). Participation was on a voluntary basis, and each student participating received a credit of 2% toward their final grade in psychology.

Equipment and materials

Experimental room. The experimental room (see Appendix I) consisted of a small table, chairs, response button, television monitor, light signal unit, and a headset to reduce extraneous noise. The headset was worn by subjects during the VMT only. A plain orange curtain hung three-quarters of the way down and spanned the width of the wall behind the television monitor and light signal. The curtain and yellow wall provided a comfortable backdrop for viewing the presentation of stimulus items.

The adjacent room housed the remainder of the apparatus which consisted of an SV-3650 ½" video tape recorder, programmer, 6-channel event recorder, manual switch for momentary light signal, and a 6-digit counter. During the VMT, the experimenter occupied this room and operated the electronic equipment.

The cognitive tests, general information questionnaire, and visual motor task questionnaire were administered in the experimental room (testing center). The experimenter occupied a chair opposite the subject during the testing.

Illumination for the VMT was provided by the lighted television screen and a 7.5 watt light plugged into a wall socket; illumination for the cognitive tests were provided by 4-40 watt florescent ceiling lights.

Description of cognitive tests. Speed of closure tests (Appendix A, B, C) were used to demonstrate closure phenomena in perception and inductive reasoning tests (Appendix D, E, F) were used to demonstrate closure phenomena in thinking. These tests were obtained from the Kit of Factor-Referenced Cognitive Tests described in the Manual (Ekstrom, R. B., French, J. W., Harman, H. H., & Derman, D., 1976). Speed of closure tests required the identification of configurations perceived in a scattered, unrelated, or unorganized visual field and inductive reasoning tests required the identification of a specific relationship demanded by a given set of data. General information on the factor-referenced cognitive tests used in this study have been documented in Table 1.

Insert Table 1 about here

Speed of closure tests

(a) Gestalt completion test. "A test suggested by the Street Gestalt Completion Test. Drawings are presented which are composed of black blotches representing parts of the objects being portrayed. The subject writes down the name of the objects, being as specific about them as possible" (Manual, 1976, p. 26).

(b) Concealed words test. "A test suggested by Thurstone's Mutilated Words. Words are presented with parts of each letter missing. The subject is to write out the full word in an adjacent space" (Manual, 1976, p. 26).

(c) Snowy pictures. "The subject is asked to identify objects which are partly obliterated by snow-like splatters" (Manual, 1976), p. 26).

Inductive reasoning tests

(a) Letter sets test. "Suggested by Thurstone's Letter Grouping. Five sets of four letters each are presented. The task is to find the rule which relates four of the sets to each other and to mark the one which does not

Table 1

General Information on Cognitive Tests

Factor	Tests	Components	Time		Scoring Formula	Comments
			Fore-Exercise	Test (each part)		
Speed of Closure	1. Gestalt Completion Test	10 pictures	no time limit	2 minutes	S = R[a]	guessing not discouraged
	2. Concealed Words Test	25 words	no time limit	4 minutes	S = R	guessing not discouraged
	3. Snowy Pictures	12 pictures	no time limit	3 minutes	S = R	guessing not discouraged
Inductive Reasoning	1. Letter Sets Test	15 items	no time limit	7 minutes	S = R	guessing discouraged
	2. Locations Test	14 items	no time limit	6 minutes	S = R	guessing discouraged
	3. Figure Classification	14 items each with 8 test figures	no time limit	8 minutes	S = R	guessing discouraged

[a]The letters S and R represent: total score (S), and number of correct responses (R).

fit the rule" (Manual, 1976, p. 80).

(b) Locations test. "Suggested from Thurstone's *Marks*. For each item, five rows of places and gaps are given. In each of the first four rows one place in each row is marked according to a rule. The task is to discover the rule and to mark one of the 5 numbered places in the fifth row accordingly" (*Manual*, 1976, p. 80).

(c) Figure classification. "This test was suggested by Thurstone's test of the same name. Each item presents 2 or 3 groups each containing 3 geometrical figures that are alike in accordance with some rule. The second row of each item contains 8 test figures. The task is to discover the rules and assign each test figure to one of the groups" (*Manual*, 1976, p. 80).

Instructions: cognitive tests. Instructions for the speed of closure and inductive reasoning tests were provided on their respective test booklet covers. Each test had its own specific instructions and sample practice items.

Scoring: cognitive tests. The cognitive tests were scored in accordance with the scoring procedure outlined in the *Manual*. Scoring keys for the cognitive tests were also provided in the *Manual*. The score for each test was represented by the number of correct responses for that test.

The instructions for the inductive reasoning tests stated that a penalty would be levied for incorrect responses. The purpose of this deceptive statement was to discourage the subject from guessing. The scoring procedure for the inductive reasoning tests does not include a correction factor for incorrect responses (see Table 1).

Description of the visual motor task. The VMT was described as an inductive reasoning task composed of two visual components (a continuous presentation of ambiguous forms on a television monitor, and a momentary presentation of a light signal); and a motor component (tapping on a response button).

The experimental setup for the three components which comprised the VMT is illustrated in Appendix I. In the experimental condition, the subject sat with the response button on his/her preferred hand side facing the television monitor and light signal. A continuous presentation of video taped stimulus items (Vanderplas & Garvin, 1959) was presented on the television monitor to provide a "complex field". The presentation of these items was independent of (a) the subject's tapping behaviour, and (b) the presentation of the light signal.

The subject was instructed that in order to solve the problem it was necessary to tap on the response button. The subject's task was to determine (a) whether tapping on the response button was responsible for the onset of the light signal or (b), whether tapping on the response button in conjunction with the stimulus items presented on the television monitor was responsible for the momentary onset of the light signal. In this task, tapping 30 times on the response button was directly responsible for the momentary onset of the light signal.

The tapping response and momentary presentation of the light signal were regarded as the fundamental components of the VMT, and together they comprised a "stage". In the present task, a stage was described by (a) a fixed component (a preselected number of taps) and (b), a variable component (the time taken by the subject to produce these taps). The number of taps required to produce the light signal was selected by means of a programmer built into the tapping response system. The programmer was also responsible for the presentation of the momentary light signal which occurred when the selected number was reached.

Stage 1 began with the first tap and ended with the presentation of the light signal, at which time the system reset automatically in preparation for the next stage. Stage 2 began with the first tap after the light signal (from Stage 1), continued for the specified number (set on the programmer), and ended with the presentation of the light signal. The present task consisted of 10 stages, each of which required 30 taps to produce the momentary light signal. The number of taps, and the number of successive stages the subject was required to complete, were predetermined by the experimenter.

The VMT was a versatile instrument for use in this type of research because a "stage" could be defined in terms of a fixed/variable, fixed/fixed, or variable/variable component (see Ferster & Skinner, 1957, for suggestions concerning various combinations of fixed and variable components). Behavioural scientists have labeled tapping response programmes of this nature "schedules of reinforcement". Behaviourists used a "reinforcer" (an event usually important to the survival of the organism) to increase the probability that a particular behaviour would occur again. Ferster & Skinner (1957) demonstrated that reinforcement schedules produced stylized records of responding. Performances generated by particular schedules have been used in the study of behaviour associated with motivation, emotion, punishment, escape, avoidance, and the effect of drugs.

In the present study, a programme consisting of tapping responses and a light signal, was considered a useful research tool and adapted for use as a problem solving task (see also Bruner, 1961). The light signal, produced by a fixed number of taps, occurred in conjunction with some stimulus on the television monitor. Subjects formulated and tested hypotheses in order to determine which of the alternatives presented was correct. Since a direct relationship was maintained between the number of taps on the response button and the onset of the light signal, an increase in the rate of responding produced a concommitant decrease in the time interval required to produce the light signal. Inductive closure was manifest by a systematic increase in responding across stages.

Visual Motor Task: construction and technical operation. The response button used in the experiment was an Otis Elevator touch button obtained from the Otis Elevator Company. The response button measured 2.5 cm in diameter and was mounted in conjunction with its accompanying raised faceplate (25.5 x 7.5 x 1.5 cm) on the felt-covered surface of a plywood box (60 x 15 x 67 cm--outer dimensions). The response button and faceplate assembly were mounted approximately one third the way down from one end of the box (cover dimensions 67 x 15 cm). At the opposite end, four rubber mounts supported the structure.

The response button, a solid unit which contained no moving parts, provided a temporary signal when activated. When the subject's finger touched the button, the circuit was activated; when the finger was removed, the circuit was immediately broken. When the finger touched the button again, the circuit was re-activated. In this way, the Otis

Elevator touch button was used to produce electronic signals (pulses). These pulses were recorded on channel 1 using a Ralph Gerbrands 6-channel event recorder (Model G 3360).

A programmer with a maximum of 36 settings was built into the Otis Elevator touch button system. In this way, the programmer could be preset by the experimenter for one of 36 positions. The selected position denoted the number of pulses required to produce the light signal. When the required number was produced, the final pulse automatically reset the system and fired the light signal so the next stage could begin. The final pulse was recorded on channel 2 of the event recorder in order that the time taken to produce the required number of responses for that stage, could be calculated by direct measurement. The final pulse also activated a 6-digit cummulative counter with manual reset button. The cummulative readout indicated the number of stages that had been completed.

Visual presentation of stimulus items. The stimulus material was recorded on Sony video tape[2] (V-32) using a DXC 3200 B & W video camera. The stimulus items were enlarged (5X magnification) from the published material using a Model 55C Mapograph[3] (direct reflecting projector/ enlarger) and recorded on video tape. The items were randomized without repetition and the time units (1, 3, 5, 7, and 9 seconds; mean 5 seconds) were randomized with repetition.

A Sony Trinitron 12-inch colour television monitor (Model KV-1201) was used to present the stimulus items; and a 28 v red light mounted on a 12.5 x 7.5 cm metal plate (centered 5 cm above the base) served as the light signal. The plate, painted black, was positioned on the top of the television monitor (front and center).

Demonstration tape of stimulus items. In order to acquaint the subject with the procedure regarding the presentation of stimulus items, a 30 sec demonstration tape was prepared. The tape consisted of (a) a 10 sec visual countdown using a Hunter Model 22C Klockcounter, and (b) a 20 sec display of stimulus items. The purpose of the countdown was to prepare the subject for the presentation of stimulus items which followed.

In the experimental condition, a 10 sec video taped countdown was also presented to the subject prior to the presentation of stimulus items. In order to provide an element of authenticity and precision, the subject was instructed not to begin tapping until after the 10 sec countdown. The time allotted for the presentation of stimulus items totalled approximately 45 minutes. All video recording was prepared on one tape with a 10 sec "blank" left between the demonstration tape and the experimental tape. This separation provided an adequate amount of time between parts.

Instructions: visual motor task. The subject was introduced to the experimental setting and seated facing the television monitor and light signal (see Appendix I). The tapping response button was located on the subject's preferred hand side.

> "Thank you for participating in this experiment. Please make yourself as comfortable as possible. This research will provide information concerning certain relationships in thinking that psychologists believe are associated with perception. In this experiment you will be required to solve a problem. The problem solving situation is comprised of: (a) the tapping response button located to your (left/right), (b) the presentation of stimulus items on the television monitor, and (c) a light signal, located on the top of the television monitor".

Demonstration:

> "The purpose of the following demonstration is designed to help you become familiar with the problem solving situation".

Tapping response button: The subject's attention was directed towards the response button and told it was an Otis Elevator touch button. The surface of the button was solid and did not require a "push". The subject was told to rest his/her arm flush against the felt surface of the box and practice tapping with the index finger of the preferred hand. The subject was reminded to touch the surface of the button with the fleshy part of the finger's surface in order to insure good contact. The subject was then asked to wear the headset and tap on the button. The subject was told that the purpose of the headset was to prevent extraneous noise from interferring with their thinking processes. The headset was removed after the demonstration.

<u>Presentation of stimulus items</u>: "In this demonstration, please view the television monitor for a 30 sec presentation consisting of a 10 sec visual countdown and a 20 sec presentation of stimulus items. The 10 sec countdown is presented in order to prepare you for the presentation of stimulus items which follow. The stimulus items are presented in order to acquaint you with what they look like. During this demonstration you are asked <u>not</u> to tap on the response button, just view the television monitor".

The experimenter then left the experimental room to provide the 30 sec demonstration. Upon returning, the subject was asked to describe what transpired on the television monitor. The subject was also asked whether he/she had any visual problems in viewing the presentation.

Light signal: The experimenter explained that he would leave the experimental room to present a momentary light signal. This light signal was manually presented and the subject was told that the experimenter would request a verbal confirmation of its presentation. The subject was also asked to identify the colour of the light signal.

Any aspect of the demonstration was repeated or clarified if necessary.

Continuation of instructions:

> "In this experiment you will be required to solve a problem. In order to solve the problem you will be required to determine (a) whether tapping on the response button is directly responsible for the momentary onset of the light signal or (b), whether tapping on the response button in conjunction with the presentation of stimulus items on the television monitor is responsible for the momentary onset of the light signal. This means that either your tapping behaviour is directly responsible for the momentary onset of the light signal, or your tapping behaviour in conjunction with some aspect of the stimulus presentation is responsible for the momentary onset of the light signal. In this experiment, the stimulus items will be presented for an

extended period of time. You will also receive a 10 sec visual countdown prior to the presentation of stimulus items. Remember, your tapping begins after the 10 sec countdown. You will also have ample opportunity to produce many light signals. When the experiment is completed, I will signal you by allowing the red light to remain on permanently. At that time, please stop tapping. When I return after the completion of the task, you will be asked whether you thought your tapping behaviour was directly responsible for the momentary onset of the light signal, or whether your tapping behaviour in conjunction with the presentation of stimulus items on the television monitor was responsible for the momentary onset of the light signal. You will also be asked the reasons for your answer. Do you have any questions? After receiving the instructions, put on the headset, view the television monitor and begin tapping after the 10 sec countdown".

The subject was asked whether all aspects of the problem solving task were understood. If so, the subject was asked to outline the task briefly in order that the experimenter could be certain that all aspects of the task were understood correctly. If the subject had problems understanding the task or any aspect of it, the experimenter repeated the instructions either completely or partially, depending on what was not understood.

Scoring: visual motor task. All tapping and light responses were recorded on an event recorder in order to calculate a response rate for each of the 10 stages. Channel 1 recorded all tapping responses, and channel 2 recorded the light signal responses (see Appendix J). The speed of the paper tape recording the responses was 2 mm/sec.

A measurement was taken (in mm) from the first response after the light signal (or from the first response, as was the case for stage 1) to the response indicating the onset of the next light signal. This distance divided by 2 mm/sec, denoted the time for the subject to produce 30 responses. The formula [(Response/Time in sec) x 60 sec] converted the time-response data to responses per minute (see Appendix J for an example of a 10 stage programme and calculation of the response rate for stage 1). After calculations for each stage were completed, response rates for groups of two consecutive stages were summed, and a mean response rate was calculated. As a result, analysis of the data involved five stages which comprised the ten original stages (see Appendix K for a graphic representation of the response record illustrated in Appendix J).

Procedure

The following test administration sequence was followed for all subjects:

(a) General Information Questionnaire (see Appendix L). This questionnaire, which provided information concerning the student's physical and neuro physiological condition, was administered to subjects prior to involvement with the experimental tasks. Basically, the general information questionnaire served as a means of determining the eligibility of the participant. In the present study, all students were considered eligible for participation in the research.

(b) Visual Motor Task

(c) Visual Motor Task Questionnaire (Appendix M). The purpose of this questionnaire was to obtain general information concerning the subject's efforts, strategies and opinions that resulted because of their participation in the VMT. The questions that were designed for use on the visual motor task questionnaire were based on the experimenter's curiosity and interest.

(d) Speed of Closure and Inductive Reasoning tests (randomized prior to administration). The entire testing session took approximately two hours to complete.

The subject waited in the designated waiting room and was greeted by the experimenter at the appointed time. The subject was then escorted to the room which housed the video tape recorder, programmer, event recorder, and counter. This room was adjacent to the experimental room. The subject was allowed to view each of the components and then told the following reasons for housing the components in this room: (a) the operation of the mechanical equipment was too noisy, (b) the operations involved in data collection would be distracting, and (c) the experimental room wasn't convenient to house all the equipment and conduct the experiment.

Next, the subject was introduced to the experimental room and seated at the testing centre. The subject was then administered the General Information Questionnaire. The experimenter asked the questions and penned the responses on the questionnaire sheets.

The subject was then asked to sit in a chair beside the response button (chair on the left for those who preferred the right hand, chair on the right for those who preferred the left hand). The experimenter turned off the ceiling lights to allow subjects to adapt to the light provided by the television screen and the 7.5 watt light source. The experimenter sat in a chair to the left of the subject and read the instructions.

When the VMT was completed the ceiling lights were turned on and the subject was seated at the testing center to complete the Visual Motor Task Questionnaire. The experimenter asked the questions and penned the responses on the questionnaire sheets.

Randomized administration of the speed of closure and inductive reasoning tests followed. The subject was given the test booklet and asked to follow silently while the experimenter read the instructions aloud. He/she was then asked to consider the sample questions provided. If the subject had any difficulty with the sample items, the experimenter demonstrated how the correct solution was obtained. Prior to beginning, the subject was asked if he/she had any problems understanding what they were required to do. If not, the subject turned the page and testing began. Each subject completed both parts of the test.

At the time of testing, all students were asked to report any difficulties or problems seeing (a) the visual items on the cognitive tests, or (b) the visual presentation of stimulus items on the television monitor. None of the subjects, including those wearing glasses or contact lens reported any visual problems or difficulties with either task. At the completion of testing, the subject was informed that the experiment in which he/she participated, was designed to provide information concerning relationships in perception and thinking.

Design and Statistics

The data were analysed using the SPSS computer programme package (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975). The only exception was the 3 x 5 analysis of variance (ANOVA), with repeated measures on the last factor. The analysis was provided by ANOV88, a general purpose analysis of variance programme (Butler, Kamlet, & Monty, 1969). The analysis of variance for trends, and the Neuman-Keuls pairwise comparisons of response rates across stages was obtained using statistical information obtained from the ANOV88 and OPTION 8 of the SPSS ANOVA subprogramme.

In order to obtain three closure groups, subjects were grouped according to their performance on the speed of closure tests. These tests were administered to all subjects and scored according to the scoring guidelines outlined in the *Manual*. Scores from the Gestalt Completion test, Concealed Words test, and the Snowy Pictures test were converted to *z* scores, summed and averaged for each subject to obtain a closure index. Subjects scoring in the upper, middle, and lower quartiles were designated as high, moderate and low speed of closure groups respectively. Each group consisted of 20 subjects.

Scores for the Letter Sets test, Locations test, and Figure Classification test were scored according to the scoring guidelines outlined in the Manual, converted to z scores, summed, and averaged to obtain an inductive reasoning index.

Performance scores were also obtained on the 10 stages of the VMT. Response rates for groups of two consecutive stages were summed and a mean response rate was calculated. Analysis of the data involved five stages which comprised the 10 original stages. The data for the Speed of Closure tests, Inductive Reasoning tests, and the VMT are found in Appendix O.

All factor-referenced cognitive tests were composed of two parts which were separately administered to all subjects. The means and standard deviations for these measures are presented in Appendix P. These results indicate a moderate to strong tendency for individuals to demonstrate equiprobable scores with either section of the test. As a result, both parts of the cognitive tests were combined to form a composite score. The means and standard deviations for these measures are presented in Appendix Q.

Reliability coefficients (Rulon, 1939) were calculated for male and female subjects for comparison with statistical information presented in the Manual (see Table 2).

Insert Table 2 about here

Table 2

Reliability Coefficients for Male/Female Subjects

on Alternative Forms of the Factor-Referenced Cognitive Tests

		Speed of Closure		
Test	Group	*M*	*SD*	Reliability
Gestalt Completion	males[a]	12.05	3.34	.54
	females[b]	11.08	3.99	.84
Concealed Words	males	24.30	8.26	.84
	females	20.98	6.72	.71
Snowy Pictures	males	12.83	3.27	.60
	females	12.05	3.31	.54
		Inductive Reasoning		
Letter Sets	males	20.60	4.84	.80
	females	21.48	3.90	.66
Locations	males	11.73	3.99	.48
	females	11.23	4.11	.67
Figure Classification	males	104.43	30.07	.69
	females	106.23	34.03	.84

[a] *n* = 40
[b] *n* = 40

Results

Correlations

A Spearman correlation coefficient for ordinal data was obtained in order to gain information concerning the overall relationship between closure and inductive reasoning. A significant overall positive correlation was found between performance on speed of closure tests and inductive reasoning tests $\underline{r}(80)=.384$, $\underline{p} < .001$, thus supporting the first hypothesis that there would be a significant relationship between perceptual closure as manifest on speed of closure tests and inductive closure as manifest on inductive reasoning tests. This meant that individuals who scored high, moderate or low on the closure tests, tended to demonstrate similar performances on the inductive reasoning tests.

Intercorrelations were also computed among the test battery that defined the speed of closure and inductive reasoning factor in order to determine the contribution made by each test towards the overall correlation. A total of 15 intercorrelations were calculated among the speed of closure and inductive reasoning tests (see Table 3) of which two failed to reach significance. This indicated that with the exception of the Gestalt Completion/Letter Sets, and Snowy Pictures/Locations, 13 correlations reach the required level of significance. All correlations were positive and ranged from .198 to .559. These results tended to support the second hypothesis that there would be significant positive correlations between individual tests that defined the perceptual closure factor (Gestalt Completion Test, Concealed Words Test, Snowy Pictures Test) and the individual tests that defined the inductive closure factor (Letter Sets Test, Locations Test, Figure Classification Test).

Insert Table 3 about here

A positive relationship between the high closure group and performance on the inductive reasoning tests $r(20) = .366$, $p < .056$, approached the .05 level of significance required for acceptance. This would suggest that high closure subjects tended to score high on the inductive reasoning tests. The correlation coefficient for moderate and low closure groups failed to reach significance $r(20) = .26$ $p < .134$; and $r(20) = .098$, $p < .341$, respectively. The results partially supported the third hypothesis. All correlations between performance on speed of closure and inductive reasoning tests for the high, moderate, and low closure group were positive; however, they were not significant.

Table 3

Correlation Matrix for the Factor-Referenced Cognitive Tests[a]

	GC	CW	SP	LS	LT	FC
GC		.450**	.438**	.161	.221*	.280**
CW			.331**	.338**	.247*	.317**
SP				.198*	.125	.399**
LS					.512**	.559**
LT						.371**
FC						

[a] $n = 80$

*$p < .05$

**$p < .01$

Code	Variable
GC	Gestalt Completion Test
CW	Concealed Words Test
SP	Snowy Pictures Test
LS	Letter Sets Test
LT	Locations Test
FC	Figure Classification Test

Analysis of variance

A single factor ANOVA for high, moderate, and low closure groups on the inductive reasoning tests (Appendix R) revealed a significant difference among scores obtained by the three closure groups $\underline{F}(2, 57)=7.813$, $\underline{p} < .01$. The result supported the fourth hypothesis that there would be a significant difference between the performance of high, moderate, and low closure groups on the inductive reasoning tests.

Eta-squared (or correlation ratio), which is the proportion of variance in the dependent measure (inductive reasoning) accounted for by the independent measure (closure), was performed on the data. The closure factor explained approximately 21.5% of the variability in the inductive reasoning scores for three groups.

A Neuman-Keuls test for post-hoc pairwise comparisons for three closure groups (see Table 4) found a significant difference between moderate/low, and high/low closure groups for performance on the inductive reasoning tests. In both cases, high and moderate closure groups performed significantly better than the low closure group.

Insert Table 4 about here

A 3 x 5 ANOVA with repeated measures on the stages factor (see Meyer & Noble, 1958) was performed on the

Table 4

Neuman-Keuls Multiple Comparisons of Inductive Reasoning Performance for Three Closure Groups Using *Q* Scores

Groups	Low Closure	Moderate Closure	High Closure
Low Closure		4.39*	5.20*
Moderate Closure			.81
High Closure			

*$p < .05$

response measures obtained on the VMT (Appendix S). The independent variable was the high, moderate, and low closure groups, and the dependent variable was a measure of the subject's mean response rate per block of two consecutive stages for five blocks of stages (see Table 5). The data failed to support the hypothesis of a significant groups effect (Hypothesis 5). This meant that the mean response rate for the three closure groups did not differ significantly. However, a significant stages effect $F(4, 228)=5.515$, $p < .001$ was found. The significant main effect for this factor indicated that the mean response rate changed during the blocks of stages. The criterion was the response rate in producing 30 taps per stage in the course of solving the VMT problem.

Insert Table 5 about here

A significant groups X stages interaction was found $F(8, 228)=2.04$, $p < .05$, indicating a significant difference in the response rate across stages for subjects in the high, moderate, and low closure groups. A Neuman-Keuls test for post-hoc pairwise comparisons for three closure groups (see Table 6) found a significant difference between stage 1 and stages 2, 3, 4, and 5; and between stage 2 and stage 5 for the high closure group. Multiple comparisons

Table 5

Response Rate for Three Closure Groups on the Visual Motor Task

Group[a]	Stages (responses per minute)				
	1	2	3	4	5
High Closure	77.9	105.3	118.9	129.9	135.9
Moderate Closure	93.4	106.4	114.5	106.9	104.8
Low Closure	102.4	96.8	111.3	107.2	110.3

[a] *n* = 20 subjects per group

for the moderate and low closure groups indicated no significant pairwise differences between stages for either group.

Insert Table 6 about here

An ANOVA for trends was performed on the stage means for each closure group in the VMT (Appendix T). The primary objective of the analysis was to determine whether the trend of the means for each group can be regarded as meeting the requirements of statistical significance. The analysis revealed that the response means for the high closure group demonstrated a significant linear trend $F(1, 228)=30.236$, $p<.001$. The stage means of the moderate and low closure group failed to reach significance. The results supported the sixth hypothesis that the high closure group would be more effective at inductive problem solving on the VMT than either the moderate or low closure group by demonstrating a tendency to systematically increase responding across stages. This response trend met the required level of significance for linearity.

Visual motor task questionnaire

The purpose of the visual motor task questionnaire was to obtain general information concerning performance, observations, strategies, conclusions and opinions of

Table 6

Neuman-Keuls Multiple Comparisons on the Visual Motor Task for Three Closure Groups Using Q Scores

High Closure					
Stages	1	2	3	4	5
1		3.386*	5.066*	6.433*	7.171*
2			1.679	3.047	3.785*
3				1.367	2.105
4					.748
5					

Moderate Closure					
Stages	1	5	2	4	3
1		1.147	1.613	1.673	2.609
5			.195	.255	1.192
2				.060	.996
4					.936
3					

Low Closure					
Stages	2	1	4	5	3
2		.693	1.281	1.668	1.793
1			.588	.975	1.099
4				.387	.511
5					.124
3					

*$p < .05$

subjects participating in the VMT. The relevant information is reported below.

In question 1 of the visual motor task questionnaire the subject was shown a 42 x 28.5 cm illustration of Appendix N. Appendix N presented three different displays of light patterns occurring over the 10 stages of the task. Light pattern A represented a random sequence of light signals (random response pattern). Light pattern B represented a sequence of light signals which tend to occur at a faster rate of presentation toward the latter stages of the VMT (increased response pattern). Light pattern C represented a sequence of light signals which demonstrated no systematic tendency to increase or decrease in rate of presentation (steady state response pattern). A fourth category designated "other" was also included for consideration.

The subject was asked to select one of the following light pattern categories which he/she felt "best" represented what they produced in the problem solving task: Pattern A, Pattern B, Pattern C, or "other". The purpose of the inquiry was to determine whether subjects demonstrated a preference for a particular light signal pattern among the choices presented. The results indicated that subjects demonstrated equally likely preferences for patterns A, B, and C (see Table 7).

However, the random pattern (pattern A) tended to be preferred by the majority of subjects (35%).

Insert Table 7 about here

In question 2, subjects were asked to state their conclusion to the problem underlying the light-tapping relationship by selecting one of the following choices:

A - tapping on the response button was directly responsible for the momentary onset of the light signal.

B - tapping on the response button in conjunction with the presentation of stimulus items on the television monitor was directly responsible for the momentary onset of the light signal.

C - other

The majority of the subjects selected choice A (37.5%) followed by choice C (35%) and choice B (27.5%). Since the task required 30 taps to produce the light signal, choice A was correct. Subjects were also asked the basis for their selection (question 3). The majority of the subjects who selected choice A stated that counting the number of taps and noting the onset of the light signal provided the necessary data to solve the problem. A résumé of selected responses for each of three choices can be found in Appendix U.

Table 7

Absolute and Relative Response Frequency for Questions One and Two of the Visual Motor Task Questionnaire

		Frequency	
		Absolute	Relative
Question 1.	Pattern of Light Signals Across Stages		
	Pattern A (random response pattern)	28	35.0%
	Pattern B (increasing response-rate pattern)	22	27.5%
	Pattern C (steady state pattern)	19	23.7%
	Other	11	13.7%
Question 2.	Light-Tapping Relationship		
	A - tapping on the response button was directly responsible for the momentary onset of the light signal	30	37.5%
	B - tapping on the response button in conjunction with the presentation of stimulus items on the television monitor was directly responsible for the momentary onset of the light signal . .	22	27.5%
	C - other	28	35.0%

Of the 30 subjects who selected choice A, 19 were able to identify the correct solution to the VMT. This group was identified as the visual motor task problem solvers (VMT prob. solv.), and represented approximately 24% of the 80 subjects participating in the study. The VMT prob. solv. group consisted of members from the following closure groups:

Group	Number of Subjects
High Closure	7
Transition Group[a]	4
Moderate Closure	2
Transition Group[b]	1
Low Closure	5
Total	19

---

[a] Group's closure scores lie between scores obtained by the high and moderate closure group.

[b] Group's closure scores lie between scores obtained by the moderate and low closure group.

In a comparison of *z* score means for the inductive reasoning tests, the VMT prob. solv. group attained a higher mean score than either the high, moderate or low closure groups (see Table 8). This would suggest that successful performance on the VMT by the VMT prob. solv. group can be attributed, in part, to inductive reasoning.

Insert Table 8 about here

An ANOVA for trend was performed on the following response means (Stages 1 to 5) for the VMT prob. solv. group: 106.4, 114.3, 121.2, 126.6, and 129.3. The analysis for trend $F(1, 72)=3.4$, $p<.07$ revealed that the response means for this group did not reach the accepted level of significance for linear trend. However, the VMT prob. solv. group tended to demonstrate a response trend similar to that obtained by the high closure group (see Table 5).

The strategies used by subjects were many and varied (question 4). This information is documented in Appendix V under two major categories: counting and tapping. A "miscellaneous" category was included for those strategies which could not be classified under the major categories. Counting strategies are listed under three sections: (a) discrete counting, (b) light-signal presentations and (c), visual presentation of stimulus items. Strategies which involved tapping are listed under four sections: (a) tapping rate, (b) tapping pressure, (c) visual presentation of stimulus items and (d), light-signal presentations.

Table 8

Z Score Means and Standard Deviations for

Four Groups on the Inductive Reasoning Tests

High Closure[a]		Moderate Closure[a]		Low Closure[a]		VMT prob. solv.[b]	
M	SD	M	SD	M	SD	M	SD
.264	.628	.136	.716	-.559	.772	.344	.968

[a]n = 20 subjects

[b]n = 19 subjects

Discussion

The results tended to support the two general hypotheses: (a) closure phenomena, primarily investigated in perception, can be found to occur in thinking, and (b) functional properties underlying structured wholes in perception (tendency to closure) possess the same or similar functional properties in thinking. This implied that structural tendencies underlying closure phenomena in perception can be found in thinking. Problem solving tasks that utilized inductive reasoning ability were selected to demonstrate closure phenomena in thinking. Dependent measures obtained from inductive reasoning tests and the VMT, were used to demonstrate significant relationships between closure in perception and closure in thinking.

Correlations

Performance on the inductive reasoning tests correlated .38 with performance on the perceptual closure tests. Although significant beyond the .001 level of acceptance, the correlation coefficient indicated a moderate relationship between performance on the perceptual closure and inductive reasoning tests. This moderate relationship suggested that "other" processes may be involved. External sources could as well influence the thinker. Wertheimer (1959) stated that "various conditions, forces, factors determine a structure for the subject--

factors which often include inertia of habits, piecemeal attitudes, and the working of the very Prägnanz tendency in the direction of premature closure" (p. 243).

A correlation coefficient was also calculated for each of three closure groups. Correlation coefficients were calculated in order to determine whether a significant relationship existed between closure scores obtained by three closure groups and their inductive reasoning scores. Individuals who scored high on the closure tests (high closure group) tended to score high on the inductive reasoning tests. The relationship between closure and performance on the inductive reasoning tests by the high closure group correlated .37 and bordered on significance ($p < .056$). This relationship was not significant for either the moderate or low closure group. This meant that inductive reasoning scores for the moderate and low closure group did not reflect a significant correspondence with their perceptual closure scores.

Analysis of Variance

Performance measures for three closure groups indicated that the high and moderate closure groups performed significantly better on the inductive reasoning tests than the low closure group. These results were interpreted to mean that the low closure group failed to demonstrate the same degree of flexibility in formulating and testing hypotheses as the high and moderate closure groups. Koffka (1935) attributed individual differences in performance to a difference in process distribution (a correspondence between phenomenal and real things). He explained that "in one person a process distribution will be more isolated and more rigid than in another, so that an organization once produced will be harder to change" (Koffka, 1935, p. 633).

A problem situation was considered an "open situation" (I. A. Taylor, 1960) or an "open gestalt" (Reiser, 1931) which created a demand for a solution. According to Reiser, it was the "function of thought to find the solution by transforming the open gestalt into a closed one" (p. 361). The purpose of the VMT was to demonstrate structural dynamics underlying inductive closure tendencies in thinking. The VMT was designed as an inductive reasoning task which required the subject to formulate and test hypotheses in a problem solving situation by tapping on a response button. Tapping response activity on the VMT was based on a general law which stated that "movements as would increase the total tension in the system are excluded, and that the dynamic situation demands such movements as will decrease the tensions" (Koffka, 1935, p. 626). Tapping provided the means to resolve the problem situation (decrease tension) through overt activity.

An ANOVA with repeated measures on the stages factor indicated a significant group x stages interaction on the VMT (see Fig. 1).

Insert Figure 1 about here

The interaction indicated a significant difference in response rate across stages for three closure groups. The response means for the high closure group demonstrated a significant linear trend across stages. In the VMT, the tapping responses and light signal were coordinated so that an increase in response rate increased the probability of producing a light signal. The general tendency for response rate increases across stages varied for each group. The high closure group demonstrated a systematic but stable increase in response rate and the moderate and low closure group demonstrated an unstable increase in response rate. Koffka (1935) stated that "a completed task is a closed whole and therefore leaves a trace of a well organized and stable nature, while the traces left by the incompleted tasks, now that they do not have the tension towards completion, lack this stability which derives from complete closure" (pp. 339-340). The linear trend produced by the high closure group indicated a well organized and stable performance in comparison to

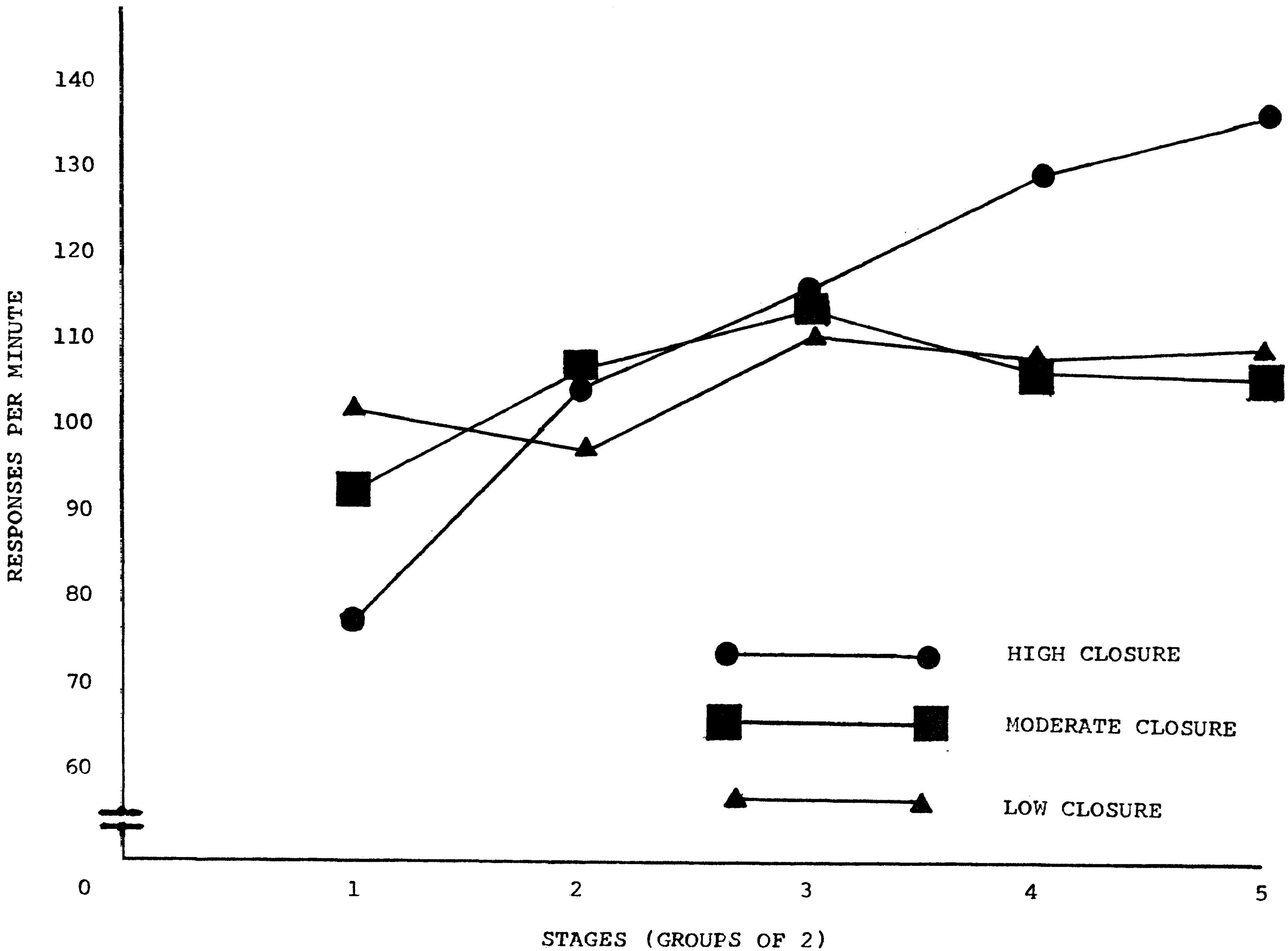


Figure 1. Response rates for three closure groups at each of five stages on the visual motor task.

the moderate or low closure group. Pairwise comparisons of stage means for the high closure group indicated a significant difference between stage 1 and stages 2, 3, 4, and 5; and between stage 2 and stage 5. As well, this group produced the lowest response rate in stage 1 (77.9) and the highest response rate in stage 5 (135.9).

A high closure group (n=20), selected on the basis of high speed of closure scores and a VMT prob. solv. group (n=19), selected on the basis of solving the VMT problem were compared with regard to their tapping performance on the VMT (see Fig. 2).

Insert Figure 2 about here

The response measures for the high closure group reached the required level of significance for linear trend, and the response measures for the VMT prob. solv. group bordered on significance ($p < .07$). These results implied that structural dynamics underlying closure tendencies in thinking (VMT prob. solv. group) functioned according to the same or similar structural dynamics underlying closure tendencies in perception (high closure group). However, a replication study would be necessary to evaluate this result.

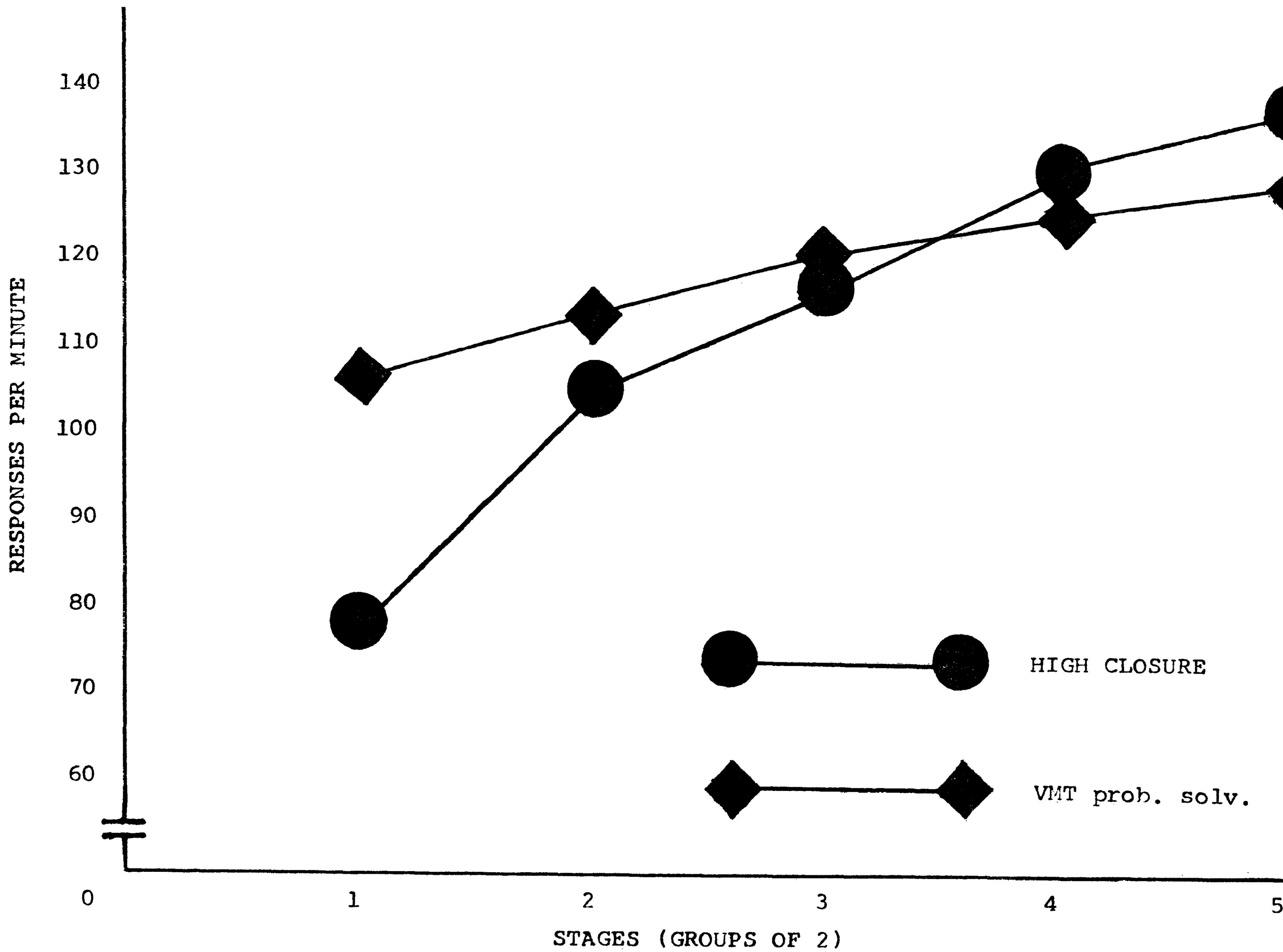


Figure 2. Response rates for VMT prob. solv. (n = 19) and high closure at each of five stages on the visual motor task.

Implications

There are a number of implications for the possible use of the VMT. The present model could be modified by implementing computer programming. This would greatly expand the VMT's capacity and allow for a greater variety and selection in programmes.

There are implications for use in medical research. Physiological measures such as heart rate, GSR, blood pressure, respiration etc., taken in conjunction with performance on the VMT could be used to determine whether tension produced in a problem solving situation has any major effects on the human system.

The VMT could be adapted for use as a psychological stressor. Programming complex problem solving situations with uncertain relationships could be successful in producing stress. As well, the VMT has implications for competitive situations.

Limitations

Certain limitations of the study should be noted. The tapping programme in the present study was limited to 10 stages. Other studies could determine the effect of varying the number of stages or imposing a "no stage limit" in a VMT problem solving situation.

The present study was limited to one programme based on the number of taps produced (30 taps produced the light signal). The VMT was considered a versatile instrument because the onset of the light signal could be made contingent upon (a) the tapping situation, (b) the presentation of stimulus items, or (c) neither (i.e., random presentation). Programmes could be devised and varied according to the needs of the research. In this way, a great variety of problem solving situations could be devised for future studies.

The calculation of tapping response rate could be better served by direct computer calculation. In this way, each stage could be subject to more complete analysis in terms of response time, non response time, response latency, grouping, etc.

Suggestions for improvement

The explanation of the components comprising the VMT (demonstration phase) required assistance. This was necessary in order to insure greater efficiency in presenting and illustrating the various components comprising the VMT (light signal, presentation of stimulus items, etc.). Moving about from one room to another during the demonstration phase was a source of distraction and may have unsettled or disturbed the participant.

The VMT was designed for single subjects. Future research may demand group administration of the VMT.

Suggestions for future research

Suggestions for future research with closure would involve investigating the relationship between perceptual acuity and performance on perceptual closure tasks. A 2 x 3 contingency table showing the relationship between high, moderate, and low closure groups and the use of correctional lens indicated that a greater number of individuals wore corrective lens in the low closure group than in the high or moderate closure group. A chi square test with 2*df* revealed that the relationship between closure and the use of corrective lens bordered on significance $\chi^2(2)=5.25$, $p < .08$. The eta-squared statistic indicated that 9% of the variability in the correctional lens variable could be accounted for by the closure groups variable. The purpose of future research in this area would be to determine whether the use of corrective lens are simply an indication of faulty physiological mechanisms, or whether the problem extends to underlying processes in the brain. The study would be comprised of three groups of individuals selected on the basis of visual acuity: myopic (nearsightedness), emmetropic (normal), and hypermetropic (farsightedness). One aspect of the research would involve performance on speed of closure tests.

Conclusion

The present study which investigated the relation between inductive closure and perceptual closure, was based on the assumption that organizational processes underlying perception apply equally to thinking. The results support the conclusion that closure phenomena, primarily explored in perception, can provide a fruitful approach to the study of closure in thinking.

A significant overall relationship was found between performance on the speed of closure tests and performance on inductive reasoning tests. The relationship between the high closure group and performance on the inductive reasoning tests bordered on significance. The high closure and moderate closure group performed significantly better than the low closure group on the inductive reasoning tests.

A 3 x 5 ANOVA with repeated measures on the last factor indicated a significant interaction effect between groups and stages. The high closure group demonstrated a significant difference in performance on the VMT in comparison to the moderate and low closure group. As well, the response measures for the high closure group demonstrated a significant linear trend. Performance by the high closure group on the inductive reasoning tests and the VMT support the gestalters claim for the generality of closure.

Inductive reasoning tests and the VMT served as useful tools for the investigation of closure phenomena in thinking.

References

Angyal, A. The holistic approach in psychiatry. American Journal of Psychiatry, 1948, 105, 178-182.

Asch, S. E. Gestalt theory. In D. Sills (Ed.), International encyclopedia of the social sciences (Vol. 6). New York: MacMillan & Free Press, 1968.

Bakay, E., & Schiller, P. H. Manipulative correction of visually presented figures. American Journal of Psychology, 1948, 61, 487-501.

Bartlett, F. B. Thinking. Manchester Literary and Philosophical Society (Manchester Memoirs), 1951, 93 (3), 31-44.

Bobbitt, J. M. An experimental study of the phenomenon of closure as a threshold function. Journal of Experimental Psychology, 1942, 30 (4), 273-294.

Bolton, N. The psychology of thinking. London: Methuen, 1972.

Bruner, J. S. The act of discovery. Harvard Educational Review, 1961, 31, 21-32.

Butler, D. H., Kamlet, A. S., & Monty, R. A. A multipurpose analysis of variance; Fortran IV computer program. Psychonomic Journals. 1969, 2 (No. 16), 301-319. (Monograph Supplements).

Davison, G. C. The negative effects of early exposure to suboptimal visual stimuli. Journal of Personality, 1964, 1964, _32_, 278-295.

Duncker, K. A qualitative (experimental and theoretical) study of productive thinking (solving of comprehensible problems). _Journal of Genetic Psychology_, 1926, _33_, 642-708.

Ekstrom, R. B., French, J. W., Harman, H. H., and Derman, D. _Manual for kit of factor-referenced cognitive tests_. Princeton, N.J.: Educational Testing Service, 1976.

Ferster, C. B., and Skinner, B. F. _Schedules of reinforcement_. New York: Appleton - Century - Crofts, 1957.

Frederiksen, J. R. _The role of cognitive factors in the recognition of ambiguous visual stimuli_. Research Bulletin 65-23. Princeton, N. J.: Educational Testing Service, 1965.

Fuchs, W. Completion phenomena in hemianopic vision. In W. D. Ellis (Ed. and trans.), _A source book of gestalt psychology_. London: Routledge & Kegan Paul, 1938.
(Originally published, 1921).

Harrower, M. R. Organization in higher mental processes. _Psychologische Forschung_, 1932, _17_, 56-120.

Hartgenbusch, H. G. Gestalt psychology in sport (E. Koffka and W. Vinton, trans.). _Psyche_, 1927, _27_, 41-52.
(Originally published, 1926).

Helmholtz, H. The origin of the correct interpretation of our sensory impressions. In R. M. Warren and R. P. Warren (Eds. and trans.), Helmholtz on perception: It's physiology and development. New York: John Wiley & Sons, 1968.
(Originally published, 1894).

Helson, H. The psychology of gestalt. American Journal of Psychology, 1926, 37, 25-62.

Holmes, D. S. Search for "closure" in a visually perceived pattern. Psychological Bulletin, 1968, 70, 296-312.

Hubbell, M. B. Configurational properties considered "good" by näive subjects. American Journal of Psychology, 1940, 53, 46-69.

Jastrow, J. Fact and fable in psychology. Boston: Houghton, Mifflin & Co., 1901.

Johnson, M. L. Perception and thought in medical students. Proceedings of the 15th International Congress of Psychology. Amsterdam: North-Holland Publishing Co., 1959.

Koffka, K. Perception: An introduction to the gestalt-theorie. Psychological Bulletin, 1922, 19, 531-584.

Koffka, K. Principles of gestalt psychology. New York: Harcourt, Brace & World, Inc., 1935.

Köhler, W. Physical gestalten. In W. D. Ellis (Ed. and trans.), A source book of gestalt psychology. London:

Routledge & Kegan Paul, 1938.
(Originally published, 1920).

Köhler, W. The mentality of apes (E. Winter, trans.). London: Routledge & Kegan Paul, 1927. (Originally published, 1925).

Leeper, R. A study of a neglected portion of the field of learning. Journal of Genetic Psychology, 1935, 46, 41-75.

Maier, N. R. F. Reasoning in humans: On direction. Journal of Comparative Psychology, 1930, 10, 115-143.

Maier, N. R. F. Reasoning in humans: The solution of a problem and its appearance in consciousness. Journal of Comparative Psychology, 1931, 12, 181-194.

Mather, J. E., & Kline, L. W. The psychology of solving puzzle problems. Journal of Genetic Psychology, 1922, 29, 269-282.

Meyer, D. R., & Noble, M. E. Summation of manifest anxiety and muscular tension. Journal of Experimental Psychology, 1958, 55 (6), 599-602.

Meyer, L. B. Emotion and meaning in music. Chicago: University of Chicago Press, 1956.

Mooney, C. M., & Ferguson, G. A. A new closure test. Canadian Journal of Psychology, 1951, 5, 129-133.

Nie, N. H., Hull, C. H., Jenkins, J. G., Steinbrenner, K., & Bent, D. H. Statistical package for the social sciences (2nd ed.). New York: McGraw-Hill, 1975.

Pemberton, C. L. The closure factors related to other cognitive processes. Psychometrika, 1952, 17, 267-288.

Piaget, J. The mechanisms of perception (G. N. Seagrim, trans.). London: Routledge & Kegan Paul, 1969. (Originally published, 1961).

Reiser, O. L. The logic of gestalt psychology. Psychological Review, 1931, 38, 359-368.

Richards, C. S. "Closure" and gestalt notions on the visual memory of form: A review. Journal of General Psychology, 1975, 93, 95-113.

Roseman, M. Closure behavior and levels of personality integration. Journal of Personality, 1952-53, 21, 48-58.

Ruger, H. A. The psychology of efficiency. An experimental study of the processes involved in the solution of mechanical puzzles and in the acquisition of skill in their manipulation. Archives of Psychology, 1910, 2 (15), 1-88.

Rulon, P. J. A simplified procedure for determining the reliability of a test by split-halves. Harvard Educational Review, 1939, 9, 99-103.

Russell, B. The problems of philosophy. New York: Oxford University Press, 1959.

Schiller, P. H., & Hartmann, G. W. Manipulative completion of bisected geometrical figures. American Journal of Psychology, 1951, 64, 238-246.

Smith, B. H. *Poetic closure: A study of how poems end.* Chicago: University of Chicago Press, 1968.

Snyder, S., Rosenthal, D., & Taylor, I. A. Perceptual closure in schizophrenia. *Journal of Abnormal and Social Psychology*, 1961, *63* (1), 131-136.

Street, R. F. *A gestalt completion test.* Contributions to Education, No. 481. New York: Teachers College, Columbia University, 1931.

Taylor, B. An investigation of generalized closure in personality. Unpublished master's thesis, Long Island University, 1952.

Taylor, I. A. Similarities in the structure of extreme social attitudes. *Psychological Monographs*, 1960, *74*, (2, Whole No. 489).

Thurstone, L. L. *A factorial study of perception*. Chicago: University of Chicago Press, 1944.

Thurstone, L. L. Mechanical aptitude III: Analysis of group tests. *Psychometric Laboratory Report*, No. 55, University of Chicago, 1949.

Vanderplas, J. M., Garvin, E. A. The association of random shapes. *Journal of Experimental Psychology*, 1959, *57*, 147-154.

Verville, E., & Cameron, N. Age and sex differences in the perception of incomplete pictures by adults. *Journal of Genetic Psychology*, 1946, *68*, 149-157.

Wardell, D., & Royce, J. Relationships between cognitive and temperament traits and the concept of "style". _Journal of Multivariate Experimental Personality and Clinical Psychology_, 1975, _4_, 244-266.

Wertheimer, Max. The general theoretical situation. In W. D. Ellis (Ed. and trans.), _A source book of gestalt psychology_. London: Routledge & Kegan Paul, 1938. (Originally published, 1922).

Wertheimer, Max. Laws of organization in perceptual forms. In W. D. Ellis (Ed. and trans.), _A source book of gestalt psychology_. London: Routledge & Kegan Paul, 1938. (Originally published, 1923).

Wertheimer, Max. _Productive thinking_. (Enlarged edition, Michael Wertheimer, Ed.). New York: Harper & Row, 1959.

Footnotes

[1]Where both dates are given, the accompanying page number (if any) refers to the English translation of the article or book.

[2]720 m. 2370 feet. 25 micron. 1.0 m. 1 polyester backing (made in Japan).

[3]Artograph Incorporated, 529 South Seventh Street, Minneapolis, Minnesota, 55415.

List of Appendices

Appendix A

Name ____

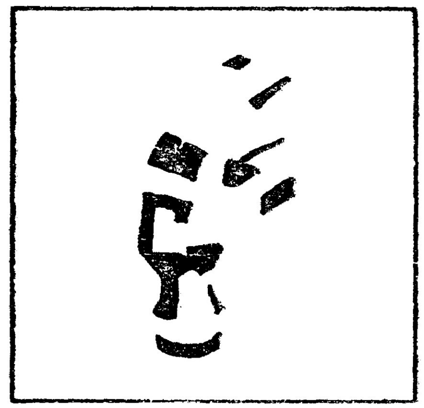
GESTALT COMPLETION TEST -- CS-1

This is a test of your ability to see a whole picture even though it is not completely drawn. You are to use your imagination to fill in the missing parts.

Look at each incomplete picture and try to see what it is. On the line under each picture, write a word or two to describe it.

Try the sample pictures below:

1. ____________________



2. ____________________

Picture 1 is a flag and picture 2 is a hammer head.

Your score on this test will be the number of pictures identified correctly. Even if you are not sure of the correct identification, it will be to your advantage to guess. Work as rapidly as you can without sacrificing accuracy.

You will have 2 minutes for each of the two parts of this test. Each part has two pages. When you have finished Part 1 (pages 2 and 3), STOP. Please do not go on to Part 2 until you are asked to do so.

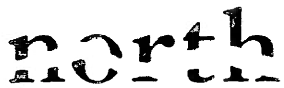
DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO

Name ____

CONCEALED WORDS TEST -- CS-2

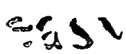
This is a test of your ability to read a word when parts of the word have been erased. Look at the words printed below. The word north has been completely printed the first time; the second time parts of the letters have been erased.

north



Now look at the sample items below. Parts of each word have been erased. Try to read what each word is. Write your answers on the lines provided. All the words used in this test will be at least four letters long. No word will contain any capital letters.

1.  ______________________________

2.  ______________________________

3.  ______________________________

Did you recognize the words as 1. parents, 2. easy, and 3. giant?

Your score on this test will be the number of correct answers that you write. Work as quickly as you can without sacrificing accuracy. If some words are difficult, skip them, and return to them later if you have time.

You will have 4 minutes for each of the two parts of this test. Each part has 25 items on two pages. Be sure to do the items on both pages if you have time. When you finish Part 1 (pages 2 and 3), STOP. Do not go on to Part 2 until asked to do so.

DO NOT GO ON TO THE NEXT PAGE UNTIL ASKED TO DO SO.

Name ______________________________

SNOWY PICTURES -- CS-3

It is helpful to be able to see objects quickly in spite of their being partially concealed by snow, rain, haze, darkness, or other visual obstructions. In this test you will be asked to recognize hard-to-see objects.

Look at the picture below. What object do you see?

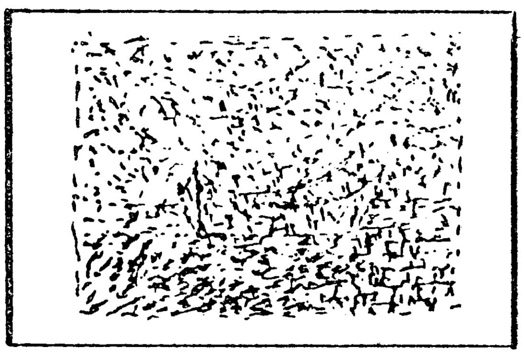
Sample Item 1:

1. anchor

By looking carefully at this sample you will see an anchor. The word anchor has been written on the line under the picture.

Now try another sample. Write the name of the object on the line provided.

Sample Item 2:



2. ______________________________

The picture shows a small boat sitting in the water. Boat, rowboat, or other similar words would be correct answers.

Your score on this test will be the number of objects that you name correctly. Work as quickly as you can without sacrificing accuracy. If some pictures are difficult, skip them and return to them later if you have time.

You will have 3 minutes for each of the two parts of this test. Each part has one page with 12 objects to identify. When you have finished Part 1, STOP. Do not go on to Part 2 until asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

Name ____

LETTER SETS TEST -- I-1 (Rev.)

Each problem in this test has five sets of letters with four letters in each set. Four of the sets of letters are alike in some way. You are to find the rule that makes these four sets alike. The fifth letter set is different from them and will not fit this rule. Draw an X through the set of letters that is different.

NOTE: The rules will not be based on the sounds of sets of letters, the shapes of letters, or whether letter combinations form words or parts of words.

Examples:

A.	NOPQ	~~DEFL~~	ABCD	HIJK	UVWX
B.	NLIK	PLIK	QLIK	~~THIK~~	VLIK

In Example A, four of the sets have letters in alphabetical order. An X has therefore been drawn through DEFL. In Example B, four of the sets contain the letter L. Therefore, an X has been drawn through THIK.

Your score on this test will be the number of problems marked correctly minus a fraction of the number marked incorrectly. Therefore, it will not be to your advantage to guess unless you are able to eliminate one or more of the letter sets.

You will be allowed 7 minutes for each of the two parts of this test. Each part has 1 page. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO

Name: ______________________________

LOCATIONS TEST — I-2

Each problem in this test consists of five rows of small dashes separated into groups by blank spaces. In each of the first four rows one dash is replaced by an "x". In the fifth row five of the dashes are replaced by numbers. In each problem there is a rule guiding the placement of the "x" in each of the first four rows. You are to figure out what that rule is and to use the rule in deciding where the "x" should come in row 5. When you have picked the number in row 5 which appears where the "x" belongs, draw an X through it.

Example A:

```
Row 1   -------------- --x -----
Row 2   ----- --x-- ------------
Row 3   ------------- --x ------
Row 4   ----- --x---- ----------
Row 5   -------1-- --X--3-4 5---
```

Example A has been correctly marked. In the first four rows the "x" always replaces the third dash from the left of a group. The group is always the second group in the row. Therefore the correct answer is 2 because the number 2 replaces the third dash of the second group in row 5.

Example B:

```
-------- x----- --------
-- --------- -- x-- ----
x------- ---------------
----------- x----- -----
1------2 3---- 4-- -5---
```

In the first four rows of example B the "x" replaces the first dash in a group. The group with the "x" is always the next to last group in the row. Therefore the correct answer is 4, since the number 4 replaces the first dash in the next to last group in row 5.

You should expect to find any kind of relation or rule to explain the position of the x's.

Your score on this test will be the number marked correctly minus a fraction of the number marked incorrectly. Therefore, it will not be to your advantage to guess unless you are able to eliminate one or more of the answer choices as wrong.

You will have 6 minutes for each of the two parts of this test. Each part has one page with 14 items. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

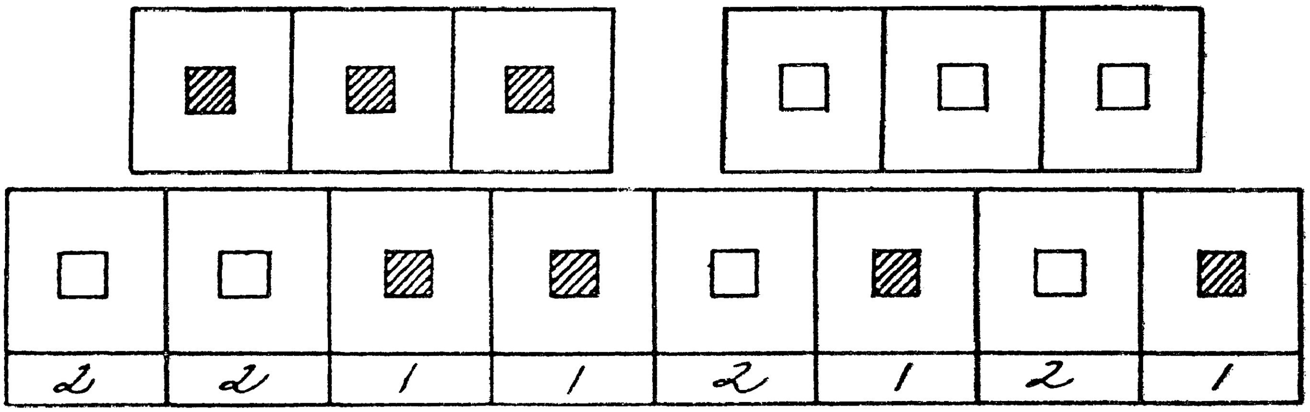
Name: ____

FIGURE CLASSIFICATION — I-3

This is a test of your ability to discover rules that explain things. In each problem on this test there are either two or three groups, each consisting of three figures. You are to look for something that is the same about the three figures in any one group and for things that make the groups different from one another.

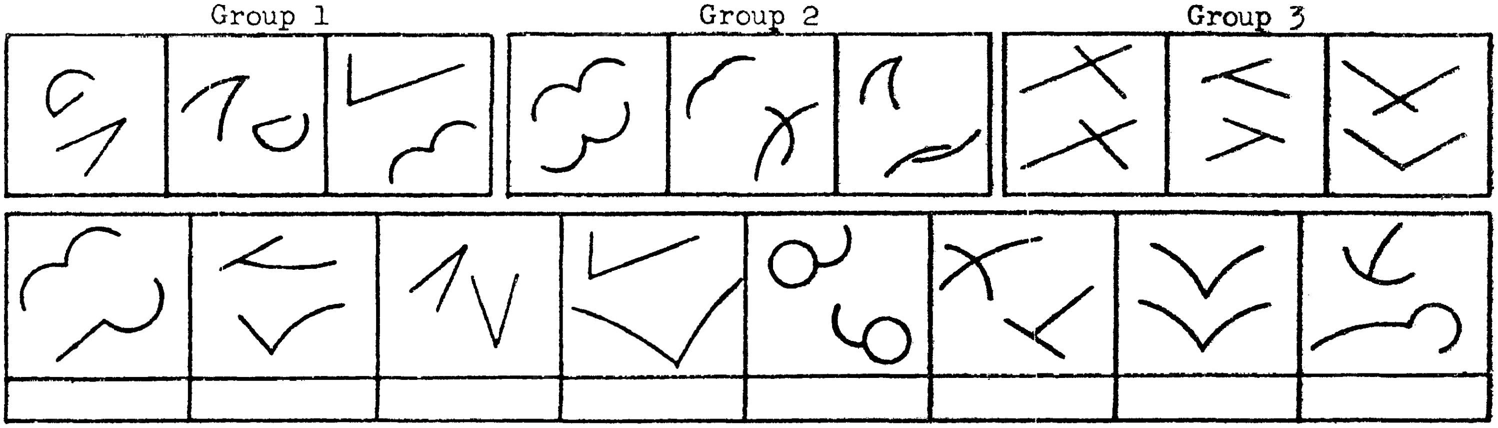
Now look at the sample problem below. In the first line, the figures are divided into Group 1 and Group 2. The squares in Group 1 are shaded and the squares in Group 2 are not shaded. In the second line a 1 has been written under each figure that has a shaded square as in Group 1. A 2 has been written under each figure with an unshaded square as in Group 2.

Group 1 Group 2



Now try this more difficult sample, which has three groups:

Group 1 Group 2 Group 3



The figures in Group 1 consist of both straight and curved lines. The figures in Group 2 consist of curved lines only. The figures in Group 3 consist of straight lines only. As you can see, there are other details that have nothing to do with the rule. The answers are: 1, 1, 3, 1, 2, 1, 2, 2.

Your score on this test will be the number of figures identified correctly minus a fraction of the number marked incorrectly. Therefore, it will not be to your advantage to guess unless you have some idea of the group to which the figure belongs.

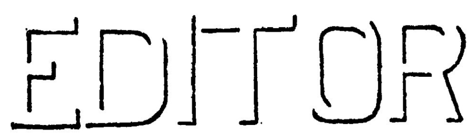
You will have 8 minutes for each of the two parts of this test. Each part has 4 pages. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

Appendix G

Letters with Incomplete Contours

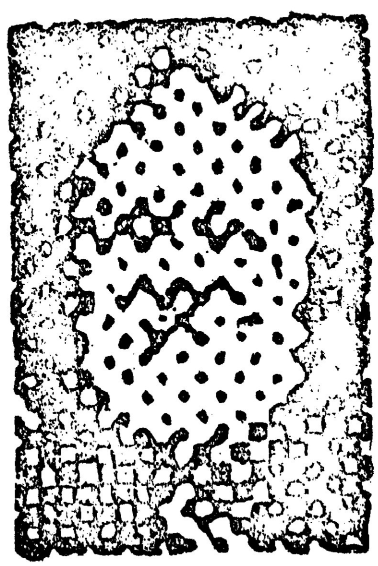
(from Jastrow, 1901, p. 281)



Appendix H

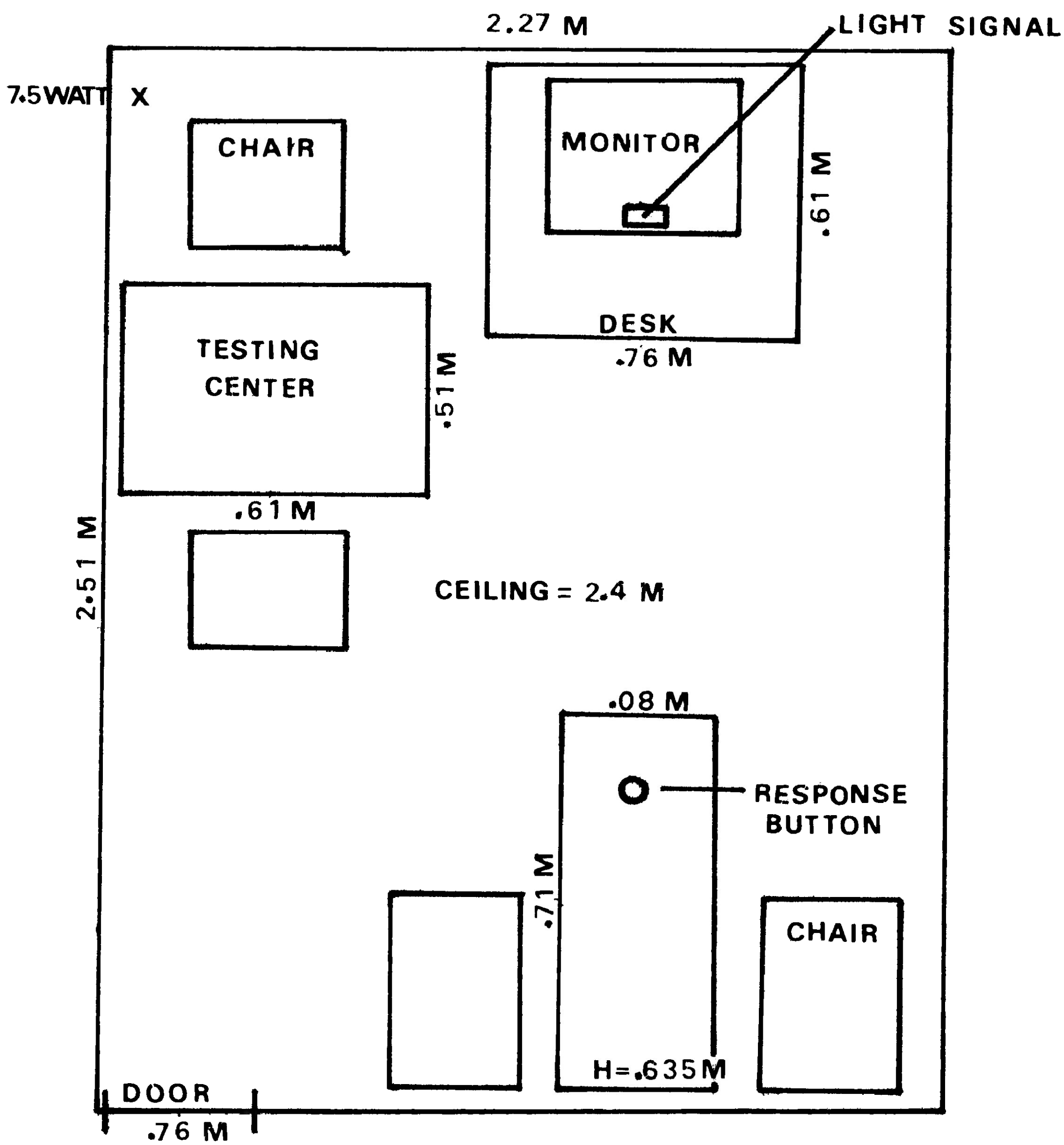
Blotched Stimulus Patterns

(from Jastrow, 1901, p. 285)



Appendix I

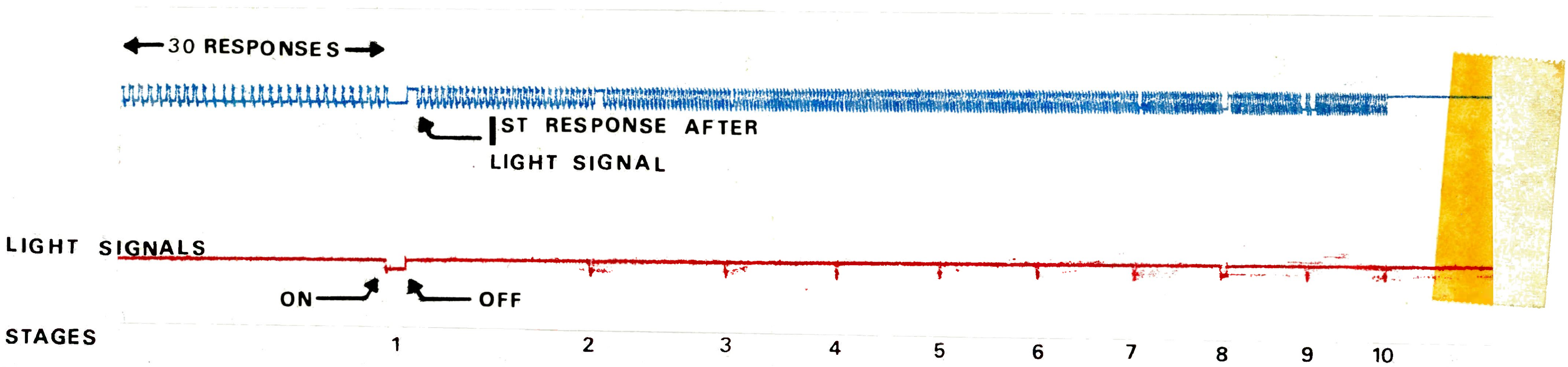
Layout of Experimental Room



Appendix J

Example of Event Recorder Printout for the Visual Motor Task,

and Calculation of Response Rate for Stage 1



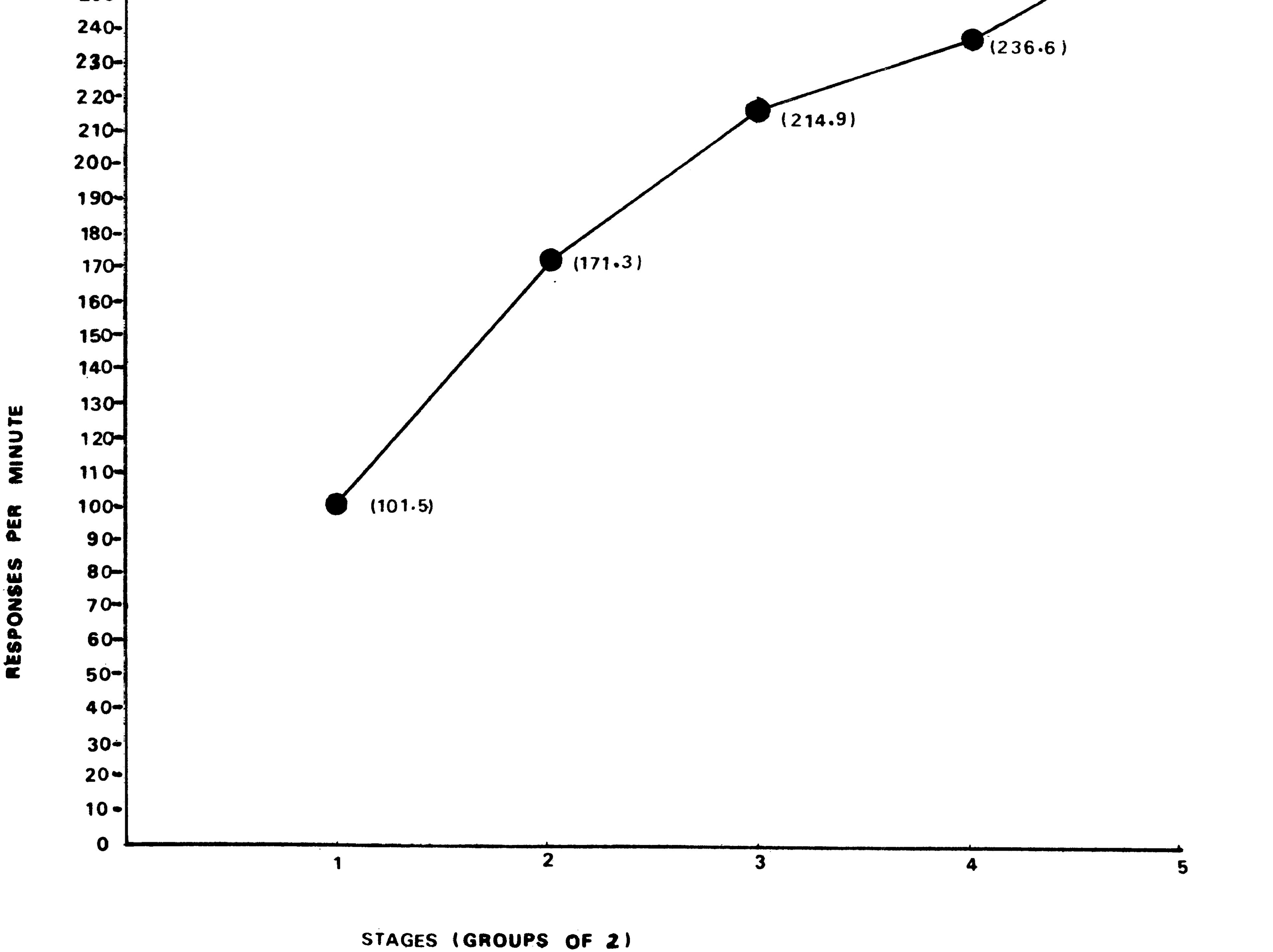
<u>Calculation of Response Rate for Stage 1</u>

Formula: Responses per minute = (Responses/Time in sec) x 60 sec	
Distance from 1st response to light onset	44.5 mm
Rate of paper flow	2.0 mm/sec
Time to complete stage 1 = 44.5/2 =	22.3 sec
Number of responses produced	30.0
Rate of responding = (30/22.25) x 60 =	80.9 responses per minute

Appendix K

Graphic Representation of Response Rate Across

Stages for Data of Appendix J



Appendix L

General Information Questionnaire

Date ______________

Room temperature ____ ^{o}C

Name: ____
(first) (initial) (last)

Address: ____

City: ____

Age: ____________________
(years) (months)

Sex: Male ______ Female ______

Introductory psychology professor ____________________

University year: ___________

Psychology courses taken:

1. Do you have any knowledge about this experiment?

   No ____

   Yes ____: if so, explain briefly . . .

2. Do you normally wear glasses or contact lens?

   No ____

   Yes ____: if so, are you wearing them for the experiment?

   Yes ____

   No ____

Appendix L continued...

3. Do you normally wear a hearing aid?

No _____

Yes ____; if so, are you wearing it for the experiment?

Yes _____

No _____

4. Do you suffer from any motor dysfunction?

No _____

Yes ____; if so, was the basis of the impairment:

(a) ____ neurological (i.e. cerebral palsy, multiple sclerosis, muscular dystrophy, Parkinson's disease)

(b) ____ medical (i.e. polio, cerebral hemorrhage)

(c) ____ other; (specify) ______________________

5. Do you generally suffer any of the following? (please answer yes or no)

(a) General lack of coordination

No _____

Yes ____; if so, how frequently? _______________

(b) Muscular weakness

No _____

Yes ____; if so, how frequently? _______________

Appendix L continued...

(c) Poor balance

No _____

Yes ____; if so, how frequently? _______________

(d) Other: (specify) ______________________________

how frequently? __________________________

6. Are you presently under medical supervision or have you consulted a physician recently?

No _____

Yes ____; if so, explain briefly ...

7. Have you taken any medically prescribed drugs during the past 24 hours?

No _____

Yes____; if so, (a) specify the drug ____________________

(b) explain briefly .....

Appendix M

Visual Motor Task Questionnaire

1. These are patterns of light signals occurring over time (see Appendix N). Which pattern of light signals do you feel "best" represents the pattern of light signals that you produced in the problem solving experiment?

   A

   B

   C

   D (none of the above)

2. In your problem solving efforts concerning the light-tapping relationship, which of the following statements applied to you?

   A - tapping on the response button was directly responsible for the momentary onset of the light signal.

   B - tapping on the response button in conjunction with the presentation of stimulus items on the television monitor was directly responsible for the momentary onset of the light signal.

   C - other

3. What is the basis for your conclusion (in reference to question 2)?

Appendix M continued...

4. Could you mention a few of the strategies that you used in the finger tapping experiment?

5. Which hand did you use in the finger tapping experiment?

   Right _____

   Left _____

6. Did you encounter any problems or difficulties with any part of the experiment?

   No _____

   Yes _____; if so, explain briefly....

7. Did you find any part of the experiment confusing?

   No _____

   Yes _____; if so, explain briefly....

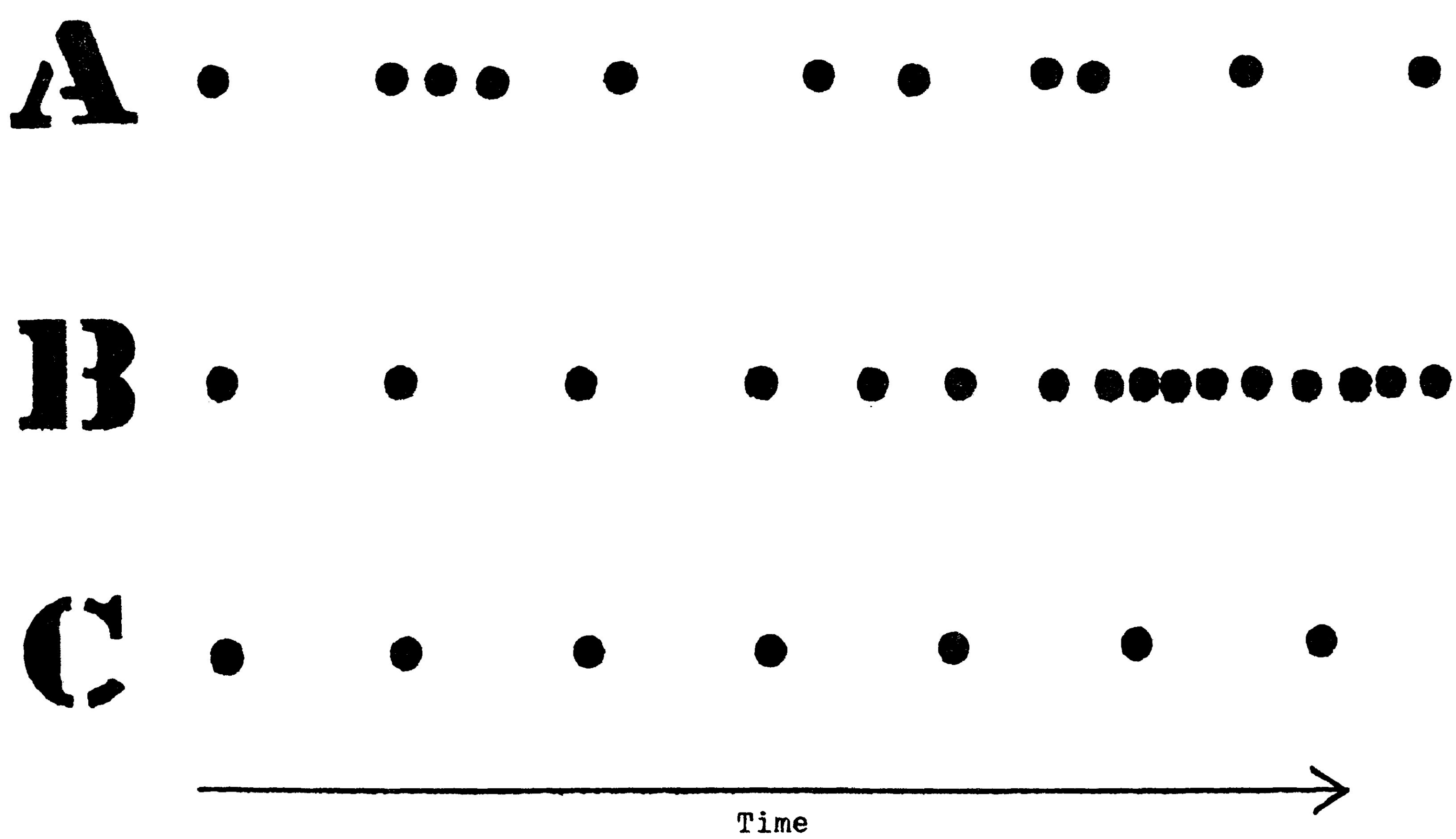
8. Did you enjoy the experiment?

   No _____

   Yes _____

Appendix N

Three Groups of Response-Signal Patterns Presented Over Time: Random Response Pattern (A), Increased Response Pattern (B), and Steady State Response Pattern (C)



Appendix O

Raw Data Scores for Factor-Referenced Cognitive Tests and the Visual Motor Task

	Factor-Referenced Cognitive Tests						Visual Motor Task				
	Speed of Closure			Inductive Reasoning			Stages (responses/min)				
Subject	GC	CW	SP	LS	LT	FC	1	2	3	4	5
1	18	40	17	26	16	110	86.4	195.9	171.5	173.5	187.3
2	7	16	10	11	7	59	181.1	162.0	343.7	162.1	167.4
3	8	13	7	21	9	47	270.0	149.5	222.9	261.9	200.7
4	19	32	15	22	11	113	68.9	69.9	72.7	72.8	73.5
5	12	18	11	18	13	86	62.5	35.1	65.5	90.1	51.8
6	7	28	10	26	11	172	35.7	40.6	57.5	105.2	90.7
7	6	14	12	22	8	95	28.0	14.1	14.9	13.2	15.3
8	15	33	18	20	8	119	62.6	164.3	164.0	158.3	194.6
9	12	29	13	22	16	180	106.2	131.0	101.4	98.1	56.7
10	10	17	7	16	8	64	134.7	134.6	133.3	133.3	133.3
11	14	20	17	19	8	116	42.0	64.1	62.0	45.6	231.4
12	11	23	13	25	9	151	54.3	47.2	59.3	38.2	89.7
13	14	19	12	28	17	146	96.5	120.9	223.4	198.7	92.9
14	13	27	15	26	15	159	26.0	26.6	28.8	35.4	149.6

Appendix O continued . . .

Subject	Speed of Closure			Inductive Reasoning			Stages (responses/min)				
	GC	CW	SP	LS	LT	FC	1	2	3	4	5
15	16	28	10	24	13	147	86.5	95.1	300.5	196.5	262.6
16	10	32	12	24	10	127	158.9	168.3	145.5	149.7	154.9
17	16	31	10	20	10	66	167.4	171.5	169.4	163.7	176.3
18	14	25	7	20	8	48	31.8	54.1	126.7	135.8	82.6
19	16	21	11	23	14	87	99.5	138.5	139.9	142.6	137.6
20	8	35	8	25	17	105	28.9	75.5	85.5	22.5	15.5
21	6	22	14	19	4	91	78.4	70.0	40.5	63.2	57.6
22	14	26	11	24	12	104	50.7	29.0	29.6	29.1	95.4
23	15	29	11	24	14	96	66.1	83.8	168.2	180.5	132.0
24	9	30	14	22	19	79	65.7	64.1	184.6	37.9	59.5
25	6	15	11	14	9	75	158.4	158.4	148.9	107.5	135.0
26	7	12	13	25	5	123	62.2	17.7	20.4	105.0	65.2
27	15	27	15	18	12	83	55.5	53.0	39.2	28.7	39.9
28	10	18	8	13	6	69	81.4	96.7	102.2	103.6	105.3
29	12	32	15	26	14	134	81.0	127.9	147.9	209.8	234.0
30	10	23	11	25	12	136	79.2	77.5	72.9	97.4	108.4

Appendix O continued . . .

	Speed of Closure			Inductive Reasoning			Stages (responses/min)				
Subject	GC	CW	SP	LS	LT	FC	1	2	3	4	5
31	11	9	11	18	12	79	51.7	41.8	42.4	37.3	40.6
32	16	23	9	18	9	105	21.3	50.8	50.7	78.3	63.4
33	8	11	7	19	13	77	30.6	25.4	35.6	30.0	31.0
34	12	23	17	16	9	94	55.2	50.8	40.9	61.8	54.0
35	11	29	17	18	6	110	52.1	81.0	162.9	363.7	353.1
36	11	11	17	22	7	85	119.0	130.1	158.3	142.6	112.9
37	16	28	15	19	8	111	127.7	184.8	232.3	236.2	236.2
38	13	35	13	25	13	134	47.2	128.3	223.3	198.2	216.2
39	10	25	15	24	9	119	35.4	36.8	39.1	83.2	78.0
40	7	19	10	25	19	133	133.8	135.9	135.9	167.2	159.9
41	9	6	18	21	11	95	145.7	203.9	255.9	259.4	216.2
42	6	11	10	23	12	92	188.5	196.5	124.7	154.9	278.6
43	11	18	9	22	16	97	277.4	284.0	268.2	214.2	140.3
44	10	32	8	25	17	100	194.8	185.7	160.0	139.9	155.0
45	15	27	13	20	16	162	360.0	272.7	125.3	186.7	128.4
46	12	19	10	27	13	129	122.1	101.6	117.2	118.1	122.1

Appendix O continued . . .

	Speed of Closure			Inductive Reasoning			Stages (responses/min)				
Subject	GC	CW	SP	LS	LT	FC	1	2	3	4	5
47	14	13	11	20	13	88	77.5	58.9	68.3	96.9	62.6
48	14	26	16	20	18	85	19.7	21.2	17.0	14.5	14.0
49	9	22	11	24	19	76	77.8	41.3	34.8	39.4	36.1
50	10	22	11	21	11	59	143.3	182.3	144.1	135.8	165.4
51	8	15	6	14	6	98	87.3	112.6	112.5	112.6	112.5
52	17	26	18	25	16	149	39.0	40.8	63.6	87.4	94.2
53	15	30	17	27	16	109	99.0	87.6	86.9	60.5	68.1
54	8	27	9	17	3	78	54.8	43.8	98.3	84.7	55.9
55	9	21	8	19	10	107	50.0	58.9	50.5	57.9	49.2
56	15	28	13	12	11	77	66.7	166.6	158.1	98.4	50.8
57	14	19	11	14	3	72	85.9	95.4	101.5	111.7	103.9
58	8	20	9	24	8	64	89.7	125.5	131.0	99.3	138.5
59	18	19	14	19	15	141	151.1	106.6	144.3	183.2	179.5
60	18	24	16	24	13	148	36.5	81.9	38.9	107.8	215.4
61	15	29	15	26	9	141	142.6	134.7	135.2	160.2	159.1
62	10	14	12	25	19	168	114.1	167.3	213.5	206.4	221.5

Appendix O continued . . .

	Speed of Closure			Inductive Reasoning			Stages (responses/min)				
Subject	GC	CW	SP	LS	LT	FC	1	2	3	4	5
63	11	2	11	24	12	78	101.4	114.3	150.4	118.1	129.8
64	17	33	18	20	14	78	52.6	66.7	58.2	60.6	67.0
65	9	23	10	19	5	45	39.5	74.4	86.3	97.6	124.2
66	5	16	6	16	10	69	96.4	91.9	149.3	120.0	96.0
67	6	14	9	23	13	93	85.3	94.9	102.2	105.9	111.7
68	16	15	16	23	8	131	77.5	78.7	69.3	60.6	50.1
69	14	31	13	23	7	90	29.5	47.6	43.1	53.2	44.3
70	16	35	17	25	16	152	151.9	167.3	232.5	133.4	145.9
71	7	21	9	14	12	85	107.7	108.4	97.2	107.5	70.6
72	17	22	15	20	15	102	55.7	66.2	79.1	123.1	62.4
73	11	24	14	23	12	115	72.8	95.2	84.7	39.4	83.3
74	13	28	13	26	15	167	190.7	163.6	175.7	180.5	215.0
75	14	25	14	16	9	126	76.7	75.2	360.0	360.0	342.9
76	7	27	17	24	11	103	139.0	192.5	212.0	154.5	171.5
77	5	13	16	18	15	128	39.8	47.6	47.9	48.8	59.9
78	11	29	17	26	15	92	128.7	113.4	106.7	75.1	82.4

Appendix O continued . . .

	Speed of Closure			Inductive Reasoning			Stages (responses/min)				
Subject	GC	CW	SP	LS	LT	FC	1	2	3	4	5
79	9	9	13	4	3	79	70.3	49.5	60.3	97.4	105.6
80	7	28	13	18	11	124	221.6	218.2	104.7	212.5	218.2

Code	Variable
GC	Gestalt Completion Test
CW	Concealed Words Test
SP	Snowy Pictures Test
LS	Letter Sets Test
LT	Locations Test
FC	Figure Classification Test

Appendix P

Means and Standard Deviations for Alternative Forms of the Factor-Referenced Cognitive Tests

Test	Part	M	SD
Speed of Closure[a]			
Gestalt Completion	A	6.68	1.54
Gestalt Completion	B	4.89	2.52
Concealed Words	A	9.66	3.54
Concealed Words	B	12.98	4.79
Snowy Pictures	A	7.69	1.95
Snowy Pictures	B	4.75	1.98
Inductive Reasoning[a]			
Letter Sets	A	10.60	2.75
Letter Sets	B	10.44	2.12
Locations	A	5.69	2.23
Locations	B	5.79	2.56
Figure Classification	A	57.51	17.92
Figure Classification	B	47.81	17.54

[a] n = 80

Appendix Q

Means and Standard Deviations for Factor-Referenced Cognitive Tests (Alternative Forms Combined)

Speed of Closure[a]		
Test	M	SD
Gestalt Completion	11.56	3.69
Concealed Words	22.64	7.67
Snowy Pictures	12.44	3.29
Inductive Reasoning[a]		
Letter Sets	21.04	4.39
Locations	11.48	4.04
Figure Classification	105.33	31.92

[a]n = 80

Appendix R

Analysis of Variance for Performance Scores on Inductive Reasoning Tests by Three Closure Groups

Source of Variation	Sum of Squares	df	Mean Square	F Ratio
Between Groups	7.83	2	3.91	7.813**
Within Groups	28.56	57	.50	
Total	36.39	59		

**$p < .01$

Appendix S

A 3 x 5 Analysis of Variance with Repeated Measures on the Last Factor for Three Closure Groups on the Visual Motor Task

Source of Variation	Sum of Squares	*df*	Mean Square	*F* Ratio
Between Subjects	818618.37	59		
A (groups)	4465.88	2	2232.94	.156
Error (*a*) (subjects within groups)	814152.49	57	14283.38	
Within Subjects	348484.57	240		
B (stages)	28858.28	4	7214.57	5.515**
A x B	21346.85	8	2668.36	2.040*
Error (*b*)	298279.44	228	1308.24	

*$p < .05$
**$p < .001$

Appendix T

Summary of a Trend Analysis for Three Closure Groups

on the Visual Motor Task

Source of Variation	Sum of Squares	df	Mean Square	F Ratio
High Closure				
Between Groups	42702.64	4		
Linear Term	39556.44	1	39556.44	30.236**
Quadratic Term	2939.96	1	2939.96	2.247
Cubic Term	151.55	1	151.55	.116
Quartic Term	54.76	1	54.76	.042
Within Groups	298279.38	228	1308.24	
Total	340982.00	232		
Moderate Closure				
Between Groups	4609.72	4		
Linear Term	1069.98	1	1096.98	.839
Quadratic Term	3004.48	1	3004.48	2.297

Appendix T continued . . .

Source of Variation	Sum of Squares	df	Mean Square	F Ratio
Moderate Closure				
Cubic Term	219.87	1	219.87	.168
Quartic Term	288.48	1	288.48	.221
Within Groups	298279.38	228	1308.24	
Total	302889.06	232		
Low Closure				
Between Groups	2892.58	4		
Linear Term	1367.13	1	1367.13	1.045
Quadratic Term	1.94	1	1.94	.001
Cubic Term	329.73	1	329.73	.252
Quartic Term	1193.85	1	1193.85	.913
Within Groups	298279.38	228		
Total	301171.94	232		

**$p < .001$

Appendix U

Résumé of Reasons for Choice of A, B, or C of Question Two (Visual Motor Task Questionnaire)

<u>Choice A</u> - tapping on the response button was directly responsible for the momentary onset of the light signal.

Selected Responses:

(a) counted.

(b) eliminated alternatives; for example, there was no connection between the onset of the light signal and the presentation of stimulus items.

(c) faster tapping resulted in a greater probability of producing the light signal.

(d) increased pressure on the tapping response button produced a brighter light signal.

<u>Choice B</u> - tapping on the response button in conjunction with the presentation of stimulus items on the television monitor was directly responsible for the momentary onset of the light signal.

Selected Responses:

(a) light signal was produced after the presentation of 4-5 stimulus items.

(b) presentation of the light signal was sometimes the function of stimulus item presentations, and sometimes the function of tapping.

Appendix U continued...

(c) light signal was produced with the onset of complex stimuli.

(d) light signal was programmed to display with the presentation of specific items.

(e) rate of tapping was correlated with rate of item presentation to produce the light signal.

(f) rate of tapping was correlated with shape of stimulus item to produce the light signal.

(g) light signal was programmed to display with the presentation of a specific pattern of stimulus items.

(h) tapping on the response button in conjunction with the presentation of stimulus items of brief duration produced the light signal.

(i) stimulus items were presented faster during presentation of the light signal, and slower during its offset.

Choice C - other.

Selected Responses:

(a) light signal was under control of the experimenter.

(b) presentation of the light signal was controlled by an independent programme.

(c) a specific pattern of stimulus items engaged the light signal and a tapping response set it off.

(d) presentation of the light signal was dependent on a specific method of tapping.

(e) light signals were programmed to occur at equal intervals of time.

Appendix V

Résumé of Strategies Used by Subjects in the Visual Motor Task

---

CATEGORY 1:

Counting Strategies

- Direct
- Light Signal
- Television Presentation

CATEGORY 2:

Tapping Strategies

- Rate
- Pressure
- Television Stimuli
- Light Signal

CATEGORY 3:

Miscellaneous Strategies

Appendix V continued...

Counting Strategies

Counting strategies are those which included a numerical description of events associated with the VMT. These events are listed under three sections: direct, light signal, and television presentation.

Direct

This section lists specific numbers reported by subjects who counted: 10, 17, 24, 25, 28, 29, 30, 35. Subjects also reported counting in groups of three or four, and using various groups of numbers in combination.

Light Signal

This section lists strategies which involved counting and the presentation of light signals as anchor points.

(a) counted the number of taps between light signal presentations.

(b) counted the number of stimulus items between light signal presentations.

(c) counted the number of stimulus items between a specific pattern and presentation of the light signal.

Television Presentation

This section lists strategies which involved counting and the presentation of stimulus items as anchor points.

Appendix V continued...

(a) counted the number of stimulus items which occurred between the presentation of selected stimulus items.
(b) counted the number of points and sides of various stimulus items.
(c) counted during the presentation of specific shapes.
(d) counted the interval between the presentation of certain pattern catagories.

Tapping Strategies

Tapping strategies are those which describe some form of tapping behaviour in conjunction with events associated with the VMT. These events are listed under four sections: rate, pressure, television stimuli, and light signal.

Rate

Subjects reported various tapping strategies associated with rate. This section lists the various approaches in tapping rate used by the subject.
(a) rest (no tapping).
(b) fast.
(c) slow.
(d) steady.
(e) variable.
(f) rhythmic.

Appendix V continued...

(g) gradual acceleration.

(h) gradual deceleration.

(i) period of rest followed by gradual acceleration.

Pressure

Subjects reported various tapping strategies which involved pressure on the response button. Pressure was exerted on the response button by the subject while tapping. This section lists various approaches used by subjects in the application of pressure.

(a) varied pressure.

(b) increased pressure.

(c) decreased pressure.

(d) rested finger on response button under pressure for various time periods before release.

Television Stimuli

Subjects considered many features of the items presented. This section lists the features of stimulus items that contributed to the formation of tapping hypothesis.

(a) complexity.

(b) shape.

(c) presentation rate.

(d) size.

Appendix v continued...

(e) number of sides.

(f) tapping with the alternate presentation of stimulus items.

(g) tapping with the presentation of stimulus items of similar type.

(h) tapped faster for stimulus presented at a faster rate.

(i) one tap with the presentation of large items, two taps for small items.

(j) slow tapping with the presentation of complex items.

(k) variation of response rate for different items presented.

(l) rested finger on response button during presentation of large items.

Light Signal

This section lists strategies which involed tapping and the presentation of light signals as anchor points.

(a) no tapping immediately after presentation of the light signal.

(b) increased tapping pressure on the response button after presentation of the light signal.

(c) an increase in tapping frequency produced an increase in frequency of light signal presentations.

(d) the light signal was produced in conjunction with the presentation of a specific stimulus item.

Appendix V continued...

Miscellaneous Strategies

Miscellaneous strategies are those that are not catagorized under counting strategies or tapping strategies.

(a) considered aspects of the demonstration in the experimental condition.

(b) YES-NO decision; sometimes the light signal was attributed to tapping behaviour, sometimes to the presentation of stimulus items.

(c) favoured one side of the response button for tapping because it initially produced a light signal.

(d) ignored the presentation of stimulus items on the television monitor.

(e) considered speed of tapping irrelevant.