PERCEPTUAL CLOSURE WITH AND WITHOUT EYE MOVEMENTS

C. M. Mooney

Submitted to the Faculty of Graduate Studies and Research of McGill University in partial fulfilment of the requirements for the degree of Doctor of Philosophy, August, 1955.

CONTENTS

Chapter		Page
I	GENERAL PURPOSE AND METHOD.....	1
II	THEORIES AND STUDIES BEARING ON CLOSURE.....	4
III	RATIONALE OF PRESENT WORK.....	28
IV	EXPERIMENTAL MATERIALS AND PROCEDURES.....	34
V	EXPERIMENTS AND FINDINGS.....	43
VI	GENERAL OBSERVATIONS AND CONCLUSIONS.....	121
VII	SUMMARY.....	138
	APPENDICES.....	140
	BIBLIOGRAPHY.....	155

TABLES

		Page
I-1	Initial Duration of Negative After-Images for Ten Adults under Six Different Flicker Frequencies	47
I-2	Initial Duration of Negative After-Images for Ten Youths under Six Different Flicker Frequencies	48
I-3	Analysis of Variance of Durations of Negative After-Images (Adults)	49
I-4	Analysis of Variance of Durations of Negative After-Images (Youths)	50
II-1	Graeco-Latin Square Design Employed in Experiment II.	53
II-2	Grouping of Test-Items According to Order of Presentation	54
II-3	Analysis of Variance Due to Different Items, Treatments, Order	55
II-4	Scores by Treatments and Order	56
III-1	Graeco-Latin Square Design Employed in Experiment III	59
III-2	Grouping of Test-Items According to Order of Presentation	60
III-3	Analysis of Variance for Real Faces "Seen"	61
III-4	Analysis of Variance for False Faces "Seen"	62
III-5	Relationship between Perception of Real Faces and False	63
III-6	Scores by Treatments and Order	64
III-7	Scores by Item-Groups and Order	65
IV-1	Graeco-Latin Square Design Employed in Experiment IV	68

		Page
IV-2	Grouping of Test-Items According to Order of Presentation	68
IV-3	Analysis of Variance Due to Tachistoscopic Speeds and Exposures	69
IV-4	Scores by Exposures and Order	70
V-1	Analysis of Variance Due to Speeds	73
V-2	Analysis of Variance Due to Speeds and Exposures	74
V-3	Scores by Exposures and Item-Groups	75
VI-1	Graeco-Latin Square Design Employed in Experiment VI	78
VI-2	Grouping of Test-Items According to Order of Presentation	78
VI-3	Analysis of Variance for Numbers of Items Perceived	79
VI-4	Analysis of Variance for Times in Seconds for Items Perceived	80
VI-5	Scores and Times (Seconds) by Treatments, Conditions, Order	81
VII-1	Scores and Times (Seconds) by Treatments, Conditions, Order	83
VII-2	Comparative Performance with Faces and Letters	84
VIII-1	Graeco-Latin Square Design Employed in Experiment VIII	88
VIII-2	Analysis of Variance between Central and Peripheral Fixations	88
VIII-3	Scores by Exposures for Central and Peripheral Fixations	89
IX-1	Perceptions with One and Two Tachistoscopic Exposures	91
X-1	Graeco-Latin Square Design Employed in Experiment X	97
X-2	Grouping of Test-Items According to Order of Presentation	97

		Page
X-3	Analysis of Variance for Items Seen	98
X-4	Analysis of Variance for Durations of After-Images	99
X-5	Mean Durations in Seconds for all After-Images	101
X-6	Mean Durations in Seconds for After-Images Seen and Not Seen	101
X-7	Mean Time in Seconds until Onset of Closure	102
XI-1	Graeco-Latin Square Design Employed in Experiment XI	106
XI-2	Grouping of Test-Items According to Order of Presentation	107
XI-3	Analysis of Variance for Real Items Perceived	107
XI-4	Analysis of Variance for Nil Perceptions	108
XI-5	Analysis of Variance for all ItemsMisperceived	108
XI-6	Mean Time in Seconds for Perceptions and Misperceptions	109
XII-1	Graeco-Latin Square Design Employed in Experiment XII	116
XII-2	Grouping of Test-Items According to Order of Presentation	117
XII-3	Analysis of Variance for Perception of Item-Negatives	118
XII-4	Scores by Treatments and Item Groups	119
XII-5	Instances of Items Reported as Seen Earlier	120
XII-6	Instances of Items Reported as Seen Earlier	120

CHAPTER I

GENERAL PURPOSE AND METHOD

This is an attempt to throw more light on two main questions that arise concerning the so-called "closure phenomenon"---namely, on the nature or manner of operation of the organizing forces that result in an instance of closure, and on the factors that account for individual differences in facility of closure. The aim is not to try to resolve these questions but, rather, to secure preliminary facts of a kind that would be useful in prosecuting these questions. As a logical point of departure, the main thesis is that eye-movements, of a scanning or inspecting kind, are neither summative in effect nor essentially contributory to perceptual closure; that it is, rather, an all-or-none accomplishment of a single glance.

The phenomenon studied is this: an observer is confronted with a configuration of sensory elements which comprise the least number of contextually salient and relevant cues necessary to predetermine the real nature of an unrevealed whole object or event; the configuration initially strikes the observer as meaningless or enigmatic; he experiences a kind of perceptual void---a period during which he contemplates the configuration without comprehension; this ends when, through some kind of perceptual transformation, the configuration suddenly and apparently fortuitously becomes meaningful and is in some sense "seen" or comprehended in terms of its essential

wholeness. This is the instance of closure. If each of many observers is confronted with many such incompletely depicted representations of objects or events there are striking individual differences in the facility with which this "seeing" occurs.

What is, or what accounts for, the instance of closure? Why are there such marked individual differences in facility of closure? Theorizing here, and subsequent experimental studies, would seem to be contingent on more information concerning such variance in perceptual closure as may be attributed to factors like, first, the physical attributes of the stimuli; second, diversity of perceptual (viewing) conditions; third, different degrees of contextual consistency within the perceptual series along with different states of subjective expectancy ("set") on the part of the observers; and, finally, the interactions between such factors.

The present study undertook to obtain more information of this kind.

One basic type of closure item was used throughout. The items were incomplete pictures of particular human heads and faces, to be seen, when "closed", in terms of sex, approximate age, position and presentation of the head or face, expression, and the like. This choice of item was dictated by the desire to have a stimulus object which could be presumed to be universally familiar and interesting, and which could be handled experimentally under diverse viewing conditions.

Since the main hinge of the study was the question of the essentiality or summative nature of visual inspection or scanning in

effecting these closures, three basic viewing conditions were called for: one, where the eyes were free to move during an ample period of time; two, where the eyes could not scan but were held to one observation point for an ample period of time; three, where the eyes were held to one observation point for a very brief period of time. These viewing conditions, as well as the test-items, were employed throughout a series of experiments where other factors that seemed to be relevant to closure were put on trial---such as the brightness and definiteness of the test-items, the consistency and authenticity of the test-item series, the state of perceptual expectancy on the part of subjects, and the effect of prior experience with the test-items in negative and reversed states. The experimental designs were, therefore, such as loaned themselved to multi-factor forms of analysis of variance.

The detailed reports of the experiments and findings which follow are preceded by a section devoted to earlier thinking and work in the field of perceptual closure, and are followed by a section devoted to some of the implications of this present work in the context of that done earlier.

CHAPTER II

THEORIES AND STUDIES BEARING ON CLOSURE

The Closure Concept

Closure is one of several Gestalt terms which, as Luchins (28) has pointed out, need clarification. However, its general meaning would be about as stated by Murphy (33).

> Closure: according to Gestalt theory, a basic principle whereby the tension initiated by a situation is resolved and the configuration (whether of behavior or of mental process) tends to as complete or "closed" a condition as the circumstances permit. An interrupted sneeze or a face in profile without a nose is an unclosed configuration which one tends to "complete".

The term was given psychological meaning and currency by Wertheimer, who coined it, and by Koffka (21) and Kohler (22) in their exposition of Gestalt theory. They pointed to it as one of the organizing forces at work in the meaningful perception of objects and events. It was one of several factors---similarity, proximity, closure, good continuation---which determined the direction (Prägnanz tendency) of perceptual organization.

Early "crucial" illustrations of these factors were based largely on visual patterns. In these, closure had a literal aptness when used to refer to the "closing" of gaps or discontinuities in lines, circles, triangles, or patterns of these. Thus, Koffka (20), remarking that "it appears that phenomena occur in connections determined by

peculiar inherent laws of relationship which have to do with "closure" and "non-closure"," pointed to a diagram of a triangle with the tip of the apex missing with the observation that "the figure exhibits "non-closure" yet indicates with a relatively high degree of certainty the direction in which "closure" is to be effected." Elsewhere (21) he observed that "closed areas seem to be self-sustaining, stable organizations" and that "the contour bounds a figure rather than segregating itself as a line from the rest of the surface, because this is the better, the more stable organization". His illustrations were again based on simple line patterns.

Such use of visual contexts afforded the simplest instances of structural "laws" which were held to operate at much more complex levels. From the beginning, a goal of main interest to Wertheimer, Koffka, and Kohler had been the discovery of the dynamics behind aspects of behavior which transcended explanation in terms of contemporary association theory. Thus, on the basis of his simple illustrations, Wertheimer (47) conceived the various Pragnanz factors as instances of a general structuring process---the evolution of the "good Gestalt". He generalized concerning "the situation" (48) and asserted that "the objective structural requirements" of the situation essentially determined its organization, and that this organization tended towards the good Gestalt---the simplest, most stable and meaningful form or concept possible under the given conditions. When he then remarked that a given situation would be more or less structured and complete, he adduced---in the instance where it

was incomplete or contained gaps---a tendency to fill in the gap, to close the whole in the over-all process of achieving a good Gestalt; nor would this closure be capricious; it would be determined by "the intrinsic nature of the whole". Kohler (24) held that Gestalt concepts "applied far beyond the limits of sensory experience", having functional implications in "the processes of learning, of recall, of striving, of emotional attitudes, of thinking, acting, and so forth". Koffka (21), like Wertheimer, felt that the issue would be crucial in the field of human thought; this "can give us the deepest insight into gestalt dynamics, the most compulsive proof of the truth of gestalt principles".

They may have over-emphasized the extent to which the organization of the outer world determined perception, learning, behavior, and the assimilation of experience; they were, nevertheless, aware of the modifying role of inner, subjective factors. Wertheimer (48) referred to "various conditions, forces, factors, which may determine a structure for the subject---factors which often include inertia of habits, piecemeal attitudes" in the imperfect perception of a situation or the incomplete resolution of an ambiguous situation. Koffka (21), in attempting to list the various situations or problems which confront the individual, arranged them in an order extending from those where "the data themselves" were the effective determinants of the way in which they would be perceived to those where "personal factors" were the effective determinants. Kohler (23) understood that "the dynamic counterpart of a "subjective" demand may become responsible for subsequent

changes in the situation". It was to get a grip on the autochthonous processes entailed here that Koffka advanced his idea of neural processes and traces, and Kohler his appositive "postulate" of psychophysical isomorphism. By such hypotheses---where, as Kohler (24) put it, "experienced order in space" and "experienced order in time" were always "structurally identical with a functional order in", respectively, "the distribution of underlying brain processes" and "the sequence of correlated brain processes"---it was possible to account for perceptual experience in terms of an entropic neural system.

A new emphasis developed, exemplified on the Gestalt side by Lewin and his associates in their dynamic approach to personality, featuring the agency of subjective determinants and underlining the idea of man-in-his world as a person-centered "field" of organizing forces. As Lewin (27) put it: "Not only such facts as valences of environmental objects and events, but also the meaning and structural peculiarities of the perceptual field depend upon psycho-biological factors of the individual concerned and are not completely or univocally determined by the objective stimulus factors...not only the content and momentary state of needs and interests, but all dynamic properties of the person, the rigidity and unchangeability of his systems, make themselves felt in the structure and changes of the physical environment."

This theme was substantially developed in subsequent work---

notably, by Stern, Wulf, Bartlett---on memory, recall, and testimony; by Rorschach, Murray, Sherif---on projection; by Allport and Postman, Sherif and Cantril, Cantril, Gaudet and Hertzog, Bruner and Goodman, Levine and Murphy---on the accommodation between subjective and objective factors in determining perception and behavior in situations of varying degrees of meaning and importance to the individuals concerned. The individual's comprehension of his physical-social world came to be seen as a bipolar process, his perceptions, on the one hand, being more or less determined by the degree of integrity and recognizability---and thereby the meaningful implications ---of the encompassing world; and, on the other hand, these constructions being more or less determined by his own constitutional organization and the degree to which his experience, needs, interests, and attitudes were well or poorly integrated and recognized. To judge by almost identical resumes by Cantril (6), Sherif and Cantril (39), Allport and Postman (3), Krech and Crutchfield (25), Murphy (33), Bruner and Goodman (5), a kind of axiom has evolved---to this effect: the more vitally concerned the observer is in the implication of a configuration of objects or events the greater will be his apprehensive concern; and, the less explicitly well-structured, complete, and familiar the configuration, on the one hand, and the less implicitly extensive, well organized, and accessible his personal experiences and capacities, on the other, so much more certainly and in so much greater degree will the construction he places upon it be determined by inner, subjective forces.

Thus, beginning with the early Gestaltists themselves, when, as noted earlier, they undertook to apply their theory to processes more complex than the apprehension of visual configurations, the concept of closure was generalized and extended as to describe any terminal imputation of meaning. It has become common to designate as "closures", "completions", or "good Gestalts" whatever serviceable constructions are placed on any of the host of symbolic or enigmatic presentations confronting men---running all the way from immediate, rational conclusions to belated, irrational surmises---as engendered by objects and events extending from the simple and concrete to the complex and amorphous. This is well illustrated, for example, by Allport and Postman (3) in their study of rumor. They speak of a "good closure" as the discovery of "a plausible reason for a confused situation"; as an experience: "We experience a good closure when we find satisfying explanations and when our view of a situation is clear and stable"; of closure as the achievement of "a better Gestalt"---"a simpler, more significant configuration"; again, as "a form of sharpening"---"the subject's urge to make his experience as complete, coherent, and meaningful as possible"; of closure and "good continuation" as a completion process---"bringing about a more coherent, consistent mental configuration"; and, again, of the propagation of a ghoulish rumor as a "moralized closure".

So generalized, closure may be thought of as a perceptual consummation; as the terminating phase of any process of comprehension;

as the outcome, in terms of some species of emergent meaning, of an act of perceptual organization. The dynamics are held to be a kind of constructive reconciliation of what Murphy (33) calls "bipolar" forces, or what Krech and Crutchfield (25) call "structural-functional" forces. There is at one extreme that closure which is unequivocally determined by the constitutional nature and contextual setting (what Sherif and Cantril speak of as "the compelling features and salient reference points") of a given presentation; and there is at the other extreme that closure which---due to the amorphous constitutional nature and contextual indeterminacy of the presentation---is equivocally determined by the constitutional nature and social context of the observer. A given closure becomes a complex function of a particular milieu or concatenation of objects, persons, and events, and is, essentially, a created meaning. Its simplest and most common manifestation would be the rapid and habitual recognitions of the commonplace items of daily communication and use---familiar spoken and written words and manifest objects---its measure being, presumably, simply perceptual speed. Beyond this, less frequent manifestations would be the comprehension of words, symbols, objects, and events which, though not completely represented, were yet sufficiently articulated to suggest their whole state. Least frequent manifestations, as one pushed on towards some ultimate level of "sufficient articulation" (unique, presumably, for the particular person involved, and for the manner or degree of involvement), would be those depleted and amorphous confrontations which admitted explanations necessarily couched in subjective,

thematic terms. Such a concept thus goes far beyond that implied in the simple graphic illustrations first offered by Wertheimer.

Now, in fact, the whole drift of this concept, from the early Gestaltists onward, is into the field of insight. The foregoing highly generalized concept of closure comes quite near, and may indeed, by synonymous with, insight. Wertheimer (48), in his discussion of insightful problem solving, remarked that for the person involved "grasping the structure of the gap and the nature of the requirements that would enable him to close it adequately" was an instance of closure. "Often this transformation actually explodes, revolutionizes the old view" of the problem situation. Similarly, Koffka (20, 21) on problem solving, equated closure and insight. Lewin (27) described "the act of insight" in similar vein---"a reorganization of the field (Kohler) closely related in many respects to the transformation of so-called ambiguous figures---a shift in the totality of internal relations".

Here, and in the work of others, Hobhouse, Kohler, Yerkes, Duncker, Maier, for example, the general and consistent idea of insight was to the effect that it was the discovery of relationships---a kind of final precipitation of meaning contingent on any or several of various predisposing conditions (close acquaintance with the problem, persistent, probing exploration of it, increasing knowledge of false leads, extent of personal involvememt and so on) occurring sometimes belatedly, sometimes suddenly, often complete and successful, sometimes not.

Obviously there is a clear affinity between closure and insight. In each, the individual is required to put a meaningful construction on a constellation of objects or events which is incomplete or unarticulated but which nevertheless gives rise to a sense of imminent structure and wholeness. A conclusion, and a particular one, seems to be demanded but is, for the time, elusive. When resolution follows we say that the person has achieved insight or effected a closure. Yet there may be a practical distinction. We have remarked that insight may be long coming, requiring a close acquaintance with the problem, calculated essays at a solution, an accumulation of special knowledge, a process of consolidation along the way, leading to the final discovery of the answer. Or, it may be more dramatic, coming as a sudden revelation, not easily explained in retrospect, since it seems not to have hinged on any studied, rational approach, or, at least, when such was under way, to have been a sudden long leap forward to the answer. It may be this undeniable "clicking" occurrence which might be especially called closure.

Again, closure may be associated with what has been called disposition rigidity by Cattell (7), and by Cattell and Tiner (8), or personality rigidity by Fisher (10), or inertia by Spearman and Jones (40). Such terms, referring to the facility or lack of facility with which the individual can, under changing circumstances, implement behavior appropriate to the momentary situation would, of course, have implications in terms of perceptual organization. Thus, Thurstone (42) has identified not only a factor which he calls "speed

and strength of closure", but a related one which he calls "flexibility of closure". Again, Goldstein's (13) concept of rigidity suggested two possible aspects---primary: "adherence to a present task in an inadequate way"; and, secondary: the appearance of such behavior "only when the individual is presented with tasks with which he cannot cope". There is Sheehan's (38) observation on the results of tests of judgement consistency, involving a closure test among others, that those persons who were most resourceful at effecting closures tended towards greater variability on the various judgement tasks entailed. Of interest, too, is Leeper's (26) finding, following the use of closure tests in studying the development of sensory organization, that once some kind of initial closure had been made "some sort of cohesive force" then worked to prevent the person from effecting a different sensory organization. Here, the work of Luchins (29) on the einstellung effect is suggestive.

However, this leads into speculations concerning the differential roles of subjective factors in perceptual exercises conducted under varying conditions; such a line would seem to be premature without more knowledge than is at present available about what goes on in the instance of a perceptual closure. As Murphy (33) and Thurstone (42) emphasize, and as we have noted earlier in our review of the evolution of the closure concept, perceptual and behavioral consummations stem from the complex association of many structural and functional forces.

The question of what happens in an individual instance of

closure brings up the matter of the underlying neural processes in most striking fashion. Take the simple instance of a "gestalt completion" picture, or a "mutilated word"; here, an original, specific object has been depleted beyond immediate recognition; a few scattered bits and pieces, meaningless in themselves, comprise an enigmatic "whole" which an observer is to identify; he regards the configuration uncomprehendingly; what presently occurs, if it occurs at all, is a sudden transformation whereby the configuration seemingly snaps together and is then and thereafter "seen" as the whole object. What is this "seeing"? How is it that a present meaningless configuration can dictate the future emergence of a meaningful structure by an appeal to organizing forces which must, presumably, stem from the unapprehended implications of past experience? What is this in terms of neural or cortical action?

Closure Studies

Fuch's (11) demonstration of completion in his studies of hemianopic vision was regarded by the early Gestaltists as proof of the closure factor postulated by Wertheimer. Patients blind in one half of the visual field nevertheless reported seeing all of such simple objects as balls and circles when these were presented so that one half of them lay, in fact, in the blind side. They reported seeing the whole object when only a half-object was presented on the good side. It seemed evident that the hemianopic subject was "completing" the configural presentation.

Gottschaldt's (14) experiments with concealed figures were not, at the time, intended as demonstrations of closure but, rather, to make the point---consistent with Gestalt determinism---that form perception was less dependent on learning than on structurally compelling features of the configuration. As we shall see later, Thurstone found that facility with the Gottschaldt figures seems to embody a closure factor.

At this point there comes to mind the considerable body of work on the "constructive" feature of the assimilation of experience---the "levelling, sharpening, embedding" aspects ---by Katona, Bartlett, Wulf, Gibson, Allport, Hebb and Foord, and others, as cited, for example, in Hilgard (18), Woodworth (49), Allport and Postman (3), Newcomb and Hartley (34), Krech and Crutchfield (25). This work rather explicitly verified the general proposition, well put in Allport's (2) words: "The first cues come from the structuration of the outer field; where these prove insufficient (as they usually do) then memory, imagination, and abstract conceptualization come to aid the process. We obtain what organization we can from the outer field and supply the remainder from within."

The first systematic attempt at the measurement of closure as a specific kind of phenomenon was by Street (41) who developed and employed a Gestalt Completion Test in a study that was intended "to furnish some data that will be useful in determining whether a hypothetical component which may be termed visual perception, exists at all; if so, to what extent it exists in some well-known tests; and

whether such visual perception has the nature of a unitary mental function capable of isolation".

The test comprised fifteen incomplete pictures of commonplace objects, presented as black and white drawings with such gaps and omissions that recognition was contingent on a mental "completion" or "closure". This final choice of items followed presentation of sixty such pictures to 754 children in grades three to nine, and the calculation of range of difficulty in terms of percent of correct responses. With two items used as examples, the test actually amounted to thirteen items. It was then given to 489 children in grades three and six, and in high school, to determine norms and reliability. Thereafter it was given to 210 sixth grade children in a battery that included the Kuhlman-Anderson test of intelligence, a sentence completion test, a dissected sentences test, a dissected words test, and the Healy 11 test. Analysis of the results clearly supported the general conclusion that the Gestalt Completion Test "measured a very specific capacity which is probably involved in the perceptual process". There were no consistent or significant differences due to sex---not unexpected, however, since Street had selected his items to minimize any such difference. The test was found to have negligible correlation with the verbal tests, and a small correlation (r: .28) with the Healy 11 which also had negligible correlation with the other tests. Thus, no factor was found common to the completion tests; and the division, so far as group factors was concerned, was between verbal and pictorial tests. Notable was the

independent and specific nature of the capacity measured by the Gestalt Completion Test. Notable also was the fact that throughout Street found no difference in scores due to age. It was this that later prompted Thurstone (42) to remark that the finding was of interest "as an indication that the test involves some factors which mature at an early age, and it may be taken as indicative of some fundamental and primitive mental function".

Street's work did not elicit much interest until picked up and extended by Thurstone some years later. However, versions of the test were occasionally employed in the interim, incidental to other studies. Leeper (26), using a score of Street-type pictures, briefly projected on a screen before groups of college students on successive occasions, demonstrated that hints and suggestions facilitated closures, and that, moreover, once a closure had been effected, the configuration in question was readily recognized thereafter. As Leeper put it, "when a sensory organization once has been achieved, whatever the factors that have produced it, there seems to be some sort of cohesive force, as one might say, that tends to prevent the person from securing any different sensory organization."

Sheehan's (38) study entailed the use of various color-, size-, weight-, and shape-matching tasks, to which was added a Street-type closure test---all for the purpose of discovering whether perceptual constancy was a consistent feature of such judgements. The results were negative, and suggested that constancy, here, was not a unitary trait; but there was some slight evidence of a tendency on the part of those

subjects who showed greatest variability in perceptual judgements "to show greater resourcefulness in the Gestalt Completion Test", leading the author to suggest "that observers in whom permanent or habitual subjective factors have operated to make the object more variable in its phenomenal aspects tend to develop greater facility in the categorical identification of objects on the basis of relatively incomplete sensory data".

Guilford and Lacey (15) in reviewing the various experimental tests developed in the wartime aviation psychology research program, described two completion tests tried out as measures of perceptual organizing capacity in the appraisal of pilot suitability. One test was Thurstone's mutilated words, and the other a gestalt completion test of the Street-picture kind. The former, comprising 25 easy items, was held to be unreliable; the latter, comprising two parts with 30 items in each, was satisfactory on grounds of reliability, but its value in pilot selection was not evident. Of main interest, perhaps, is the fact that multiple-choice answers (serving as "hints") were employed with these tests.

Verville and Cameron (45) undertook to study age and sex differences in the perception of incomplete pictures by adults---the aspect that had been experimentally minimized by Street. They developed ten Street-type pictures which, projected on a translucent screen, were shown to 100 college students (individually), aged 16 to 23, and 30 professional people, aged 35 to 56, both groups being equally divided by sex. Measures were in terms of reaction time, in fifths of a second.

They reported: for the younger group, no sex differences; for the older group, quicker reaction by the men; the younger group, as a whole, reacted more quickly than the older group; there was some evidence of "set"---that is, successful identification of, say, an animal, inclined some subjects to go on "guessing" animals in subsequent presentations; in some instances, failure on one presentation seemed to prejudice success on subsequent pictures; there was some evidence that apprehension about the purpose or use of the test (the belief that it was measuring intelligence or personality) had an inhibiting effect on closure capacity; finally, the results seemed to substantiate Leeper's finding that prompting was efficacious in securing closures.

Verville (44) extended this work, using the same materials and technique, with the purpose of assessing the effect of emotional and motivational sets on the perception of the incomplete pictures. One hundred and fifty women students were divided into five experimental groups and one control group with twenty five in each. Prior to being given the closure test, the groups were "set" in a variety of ingenious and presumably severely disturbing ways, according to principles by which they were respectively designated---i.e., tension group, complete failure group, failure by false norms group, success by false norms group, and personality testing group. The results, in terms of significantly different reaction times were as follows: negative between control and success groups; negative between success and failure by false norms groups; negative between complete failure and personality

testing groups; the tension group was slower than control, success, and failure by false norms groups, but quicker than failure and personality testing groups; the personality testing group was significantly slower than all other groups except the complete failure group. Thus, the notable points were, first, closure inhibition through dispiriting effects of prior test failure; and second, inhibition through apprehension engendered by the purported meaning of the test.

After Street, the most thorough work on closure was that done by Thurstone (42, 43). The former was the major work. In this he undertook a major analysis of factors in perception, employing factorial analysis techniques on the results of a battery of sixty tests which included versions of existing perceptual tests and additional ones of his own devising. He identified eleven common factors. Two of these ---Factor A, which he called "speed and strength of closure", and Factor E, "flexibility in the manipulation of several configurations"---he considered as "the psychologically more interesting" of the several factors, holding that it was "not unlikely that these factors will be found to represent parameters which transcend in significance the immediate perceptual content in terms of which they have been tentatively identified".

Of the eleven factors, a third one, Factor F, was called "speed of perception". Thurstone's comments on these factors are of interest:

The factor A does not seem to be adequately described merely as a speed factor. It is more than speed of closure. It represents also the strength with which a configuration is held against distraction. For this reason we have called it "speed and strength of closure". One can raise the question why speed of perception (F) should be distinguished from speed and strength of closure (A). As far as we can see now, the differentiation is concerned with a relative completeness of the sensory perception in relation to the completed percept. In speed of perception (F) the subject has no real perceptual problem. His task is merely to arrive at the percept with relatively unambiguous data.

In devising laboratory tests for the perceptual processes that may be called closure, we have already mentioned the possibility that verbal tasks might be factorially different from non-verbal tasks. Both types of closure are therefore represented in the battery. Here we shall consider another type of differentiation among tests of closure that may or may not be factorially distinct. This tentative differentiation may be considered under three heads.

(a) In the simplest case we may present the subject with perceptual material that seems at first sight to be in the nature of scattered, unrelated, and unorganized items in the visual field. At the moment of closure all the scattered items snap into a meaningful and self-consistent whole which is then perceived instead of the disparate elements. In situations where the subject has some delay in discovering the unity of the presentation, he sometimes wonders why he did not see it immediately, and he may have difficulty in again perceiving the same presentation as a disorganized field. In this case we are assuming that all the perceptual elements participate in the closure so as to leave nothing irrelevant after the closure has been obtained. The Street Gestalt Completion Test and the Mutilated Words are both examples of this type of closure, as is also the present test of Dotted Outlines.

(b) In a slightly different situation the moment of closure may bring unity into the presentation by the combination of a part of the presented items which become a figure. The remaining items in the field which are irrelevant for the figure may be perceptually discarded, or they may become depressed as the ground over which the figure is perceived. This type of closure is also in the nature of a discovery to the subject. An example of this type of closure is Hidden Digits, in which a part of the material snaps into the form of

a meaningful and consistent figure, while the remainder of the presented items fall into a ground for the figure.

(c) A still different type of closure is a presentation which is immediately and naturally perceived as a good configuration and in which the subject is asked to perceive something else. Here the subject does not succeed until he has actually destroyed the configuration before him so as to facilitate the discovery of some different configuration which is required. The hidden pictures that are frequently used in children's magazines are examples of this type of closure. The percipient must abstract away from the picture which is the manifest content of the presentation in order to discover some other kind of closure that is asked for--- the hidden picture of a dog or an Indian's head in a picture which at first sight contains no such content. In one sense, the hidden picture is a form of latent content. The Gottschaldt Figures are an excellent example of this type of closure. This type of closure involves what the Gestalt psychologists have called Gestaltbindung, which seems to refer to the rigidity of the perceived unity in a presentation. Wertheimer has described creative thinking in Gestalt terminology as the process of destroying one Gestalt in favor of a better one. In the experimental study of individual differences it might be profitable to explore these effects in search for the outcroppings of fundamental human differences in cognitive and temperamental characteristics.

Thurstone's (43) work was a study of factors possibly relevant to mechanical aptitude. Here he similarly submitted the results of a battery of thirty-two tests to factorial analysis. Included were his closure tests of the previous study. Two of the resulting factors were the same as the Factors A and E previously obtained, speed of closure and flexibility of closure. He commented:

The first closure factor...is evidently the same factor which has been called speed of closure in previous studies. The two tests which are highest in this factor in the present battery are the Street Test with a loading of .49 and Mutilated Words with a loading of .43. These are the same two tests which have identified the speed of closure factor in previous studies. The next highest saturation in this factor is that of Picture Squares (.30). Among the lower but possibly

> significant saturations on the first closure factor we find Identical Forms (.27), Mutilated Pictures (.25) and Mechanical Experience (.22). The psychological characteristic of...(this)...closure factor seems to be ability to fuse a perceptual field into a single percept. The highest saturations are in those tests in which the elements are apparently disparate in the presentation and in which the subject must unify them into a single percept. In the test with lower saturations we also have the task of formulating a closure which is more highly structured as in Identical Forms, Mutilated Pictures, and Picture Squares. Insofar as we can generalize from these few examples of the first closure factor, one may venture to guess that the first closure factor is best represented by those tests in which the perceptual field has no initial organization and in which the subject is asked to unify the field without any previous structuring.
>
> The second closure factor...has also been identified in previous studies where it was tentatively named flexibility of closure. Here, as previously, this factor is significantly represented by the Gottschaldt Figures (.30), but in the present battery there are three tests with higher saturations, namely, Copying (.36), Designs (.38), and Paper Puzzles (.32) ...
>
> The first closure factor might be associated with inductive thinking, whereas the second closure factor might be more associated with deductive thinking. The further exploration of these two closure factors and other closely related factors may prove to be psychologically fruitful.

The same factors were also revealed in later factorial studies by Botzum (4), Adkins and Lyerly (1), and Mooney (31). Such factorial approaches were not particularly informative about closure itself. They revealed marked individual differences in closure performance, and indicated that closure, as a "factor", was not correlated with reasoning "factors".

Summing up this work, it may justly be said that, apart from amply demonstrating and aptly describing the phenomenon, little light

was thrown on the questions: what happens, in an instance of closure? and why are there such marked individual differences in closure facility?

Theories of Closure

Hartmann (16), in his critical evaluation of Gestalt theory, some years ago, remarked:

> While some may protest against the spinning of intricate brain theories ad libitum because they are referred to a realm where facts elude us, nevertheless it is impossible to preserve all our hypotheses on a purely psychological level. The neural speculations which result from a search for the raison d'etre of experimental findings are not really fantastic constructions, but if properly developed lead to definite consequences which can be tested by further investigation. Ordinarily, psychological theories have been so timid and indefinite that like the planks of a political platform one can read well-nigh everything into them!

Recently, referring to the processes of perceptual organization, Zangwill (50) observed:

> The speculations of the Gestalt psychologists, ingenious as they are, do not provide us with hypotheses sufficiently precise for purposes of experimental verification. Indeed, it is likely that the dynamics of perceptual organization will ultimately be elucidated by the neurologist rather than the pure psychologist.

Gibson (12) and Hebb (17) have subsequently come forward with fairly substantial theoretical planks, the former undertaking a psychophysical, the latter a neuropsychological explanation of perceptual development and lawfulness.

Gibson (p.25) undertook to explain the "correspondence between retinal stimulation and our awareness of things" by an ultra-Gestalt-like

approach, utilizing the psycho-physical orderliness of sensory stimulation.

> What this book attempts is a direct explanation of this comprehensive correspondence. If the total stimulation contains all that is needed to account for visual perception, the hypothesis of sensory organization is unnecessary.

Well into his argument (p. 196) he has occasion to deal with the closure phenomenon and does so, briefly, as follows:

> The changes of curvature and direction around a contour which determine its shape may become enormously complex. They seem to be integrated or organized to yield qualities of a higher order. The quality of closure itself, one must admit, does not appear to be a variable quality. It goes with "thing-ness" and suggests a theory of dynamic organization which is difficult to analyze.

Other than remarking, thereupon, that "there is no reason to assume that shape cannot be reduced to its variations and that a form is unanalyzable" he deals no further with closure.

Hebb, while not denying the importance of the immediate stimulus, insists on the reality and importance of reinforcing, selective, central factors---what he calls the autonomous central process---in the mediation of perceptual events. He goes further and offers a scheme of neural growth and function compatible with what is known of both psychological and neurophysiological occurrences. Accordingly, his tentative explanations of what happens in the instance of closure are the most substantial that have so far been proffered.

His suggestion is---consistent with his neural schema---that the exitation or activation of hitherto unrelated cell assemblies, or

phase sequences can become conjoined and inter-facilitatory, by chance, or by the intervention of some persistent central, autonomous, conceptual activity so that the total neural action is a conceptual re-structuring or neo-structure.

> For the present theory, insight is a "chance" combination of facilitations from different phase sequences; but this is chance only in a limited sense, and given phase sequences that persistently return to a certain conceptual activity (motivation to solve a problem) the ultimate occurrence of insight may be quite predictable. (p. 134).

Of his model illustration (admittedly over-simplified) of how closure occurs, in the instance of a triangle with its apex missing, (pp. 103-104), he states:

> Here is an instance of Gestalt completion, but derived as an associative process, with no field forces operating. According to the schema, it could happen only with a simple and thoroughly familiar figure (or thoroughly familiar part of a complex and unfamiliar figure), which agrees with the experimental facts. It is evident that such a completion becomes a simple corollary of association, once we can provide for a perception of parts without denying the unity of the whole.
>
> So too are similarity, abstraction and generalization. Given perception of the various parts or properties of a pattern, separately; and the possibility of an association of these perceptions with a perception of the whole: we have given at once the possibility of a single response to two patterns which differ in their total properties but which have a property or properties in common. This of course is not new. What is new in the schema is showing how, conceivably, perception of part and of whole can be related to each other and to the nerve cell, and to changes at the synapse. An immediate dividend is the possibility of clearly stating, in physiological terms, the meaning of words like abstraction or similarity which are necessary to describe behavior but which have had, to say the least, a touch of mystery about them.

In this, it must be noted, Hebb places much importance on eye-movements, as he states (p. 101):

> The interrelationships of eye-movement, figure-ground segregation, and learning are explicit in the schema. Perception depends on learning first to see the parts of an object clearly, a process involving a series of visual fixations, and proceeds from seeing, at first, an amorphous mass containing several foci (the corners), to seeing a distinctive figure at a glance. Even at this final stage we know that perception of the whole is dependent on eye-movements for maximal clarity.....According to the schema, the perception is constituted by a temporal sequence of activity in suprasensory (or association-area) structures which owe their organization to changes at the synapse; it is an irregular cycle of recurring events which <u>can</u> continue momentarily without the corresponding sensory stimulations, but which is reinforced by them and by the appropriate eye-movements.

CHAPTER III

THE RATIONALE OF THE PRESENT WORK

The recognition or identification of individual objects or events or of constellations of these depends on the generalized nature of past experience and its availability on each perceptual occasion. Repeated acquaintance with various individual instances of a class of objects or events results in a scheme of likenesses---a conception---whereby on successive occasions the individual instance is seen less in terms of its unique or idiomatic character and more in terms of its membership quality. It tends to become a confirming element in a context of many other related elements in a serial perceptual process which is mainly concerned with the over-all or long-term implications of a combination or sequence of objects or events. Attention and expectation dwell less on the literal, immediate nature of single objects or events and more on their constancy and configural relevance so that they are seen only in the sense that they are noted, in the process of perceptual confirmation, as being what they are in the place and at the time they are supposed to be. In the repetitive and consistent contexts of experience there is little perception as such; there is simply a run-off of apperceptive confirmations. But this apperceptive run-off breaks down with the inexplicable disappearance or non-appearance of necessary confirming elements or by the unwarranted appearance of elements foreign to the context of emergent meaning and imminent realization. Such voiding or mutant

occurrences are nonplussing. They are the occasions for startle, astonishment, or bewilderment. They give rise to feelings of apprehensive concern and to subsequent strivings to reorient perception and to re-establish action. In these crises there is perception, but it is meaningless, it does not serve; the things seen there are incomprehensible until other aspects of the context of immediate experience, hitherto unattended to, somehow by their quality of latent structure bring into consciousness those unapprehended implications of past experience whereby insight or closure occurs and plausible meaning can be achieved within a new context.

Consider the situation where highly familiar sense-objects are so incompletely represented that there is a perceptual arrest. It has been demonstrated by Street (41), Mooney (32), and others, using graphic depictions, that when such representations are seen they are apparently seen by a sudden, fortuitous completion or closure. Disparate and, in themselves, meaningless elements of the incomprehensible whole somehow "snap together" and the thing is suddenly and surprisingly seen. Until it is seen a kind of visual quest goes on, the gaze being directed to one part and another of the representation. Other motor attempts are commonly made to come upon the percept, blinking the eyes, shaking the head, waving and turning the stimulus object when it is held.

One would suppose that the most availing method would be the searching eye-movements. It might be presumed that this would

facilitate the picking up and ultimate apperceptive assembly of the indicative cues. To suppose so would be reasonable on these other grounds: if perceptual maturation (the objectification and generalization of the sense-objects of experience) starts from and is prosecuted by eye-movements, it might be thought that, when the perceptual arrest occurs, resort to eye-movements would be a natural regression likely to be successfully reconstitutive of elements which had been initially or earlier constitutive of the percept.

Should it be demonstrable, however, that eye-movements (or successive visual fixations), of the scanning kind, are neither necessary to, nor essentially contributory to perceptual closure, then any postulated explanation of what happens in the instance of closure would have to envisage some kind of fortuitous and instantaneous arousal of a "whole". Such, tied in with other phenomenal characteristics of closure---the all-or-none, whole-or-nothing, once-seen-seen-thereafter features---would have implications for perceptual theory.

The eye-movement issue would seem to be important. Hebb (17, pp. 32-34) remarked:

> The course of perceptual learning in man is gradual, proceeding from a dominance of color, through a period of separate attention to each part of a figure, to a gradually arrived at identification of the whole as a whole: an apparently simultaneous instead of a serial apprehension.

and later:

> The factors involved are evidently complicated; it will be found, for example, that with a large figure merely

> imagining eye-movements (of following the contours) will restore definition of the figure. Also, these "imaginary" eye movements, or subliminal activations of the motor system, occur more frequently and are less easy to control in looking at a smaller than at a larger figure, and it is hard to be sure that the size of the figure is unimportant. But this at least seems definite, that a stable, clear, and effective perception of circle or square is more possible with eye movement than without. Once the question is asked, anyone can verify for himself the falsity of the implicit assumption (usually made in the study of perception) that the figure acts always as one, without a reinforcing perception of its parts as distinct from the whole.
>
> My point is not that eye-movements are essential to perception by a sophisticated observer (nor.....that they are completely necessary for an image); but that the perception is definitely clearer, more effective, with them than without. This is really an evident fact. It is to be interpreted in the light of all evidence, cited above, showing that the perception of square or circle is slowly learned and depends originally on multiple visual fixations.

Gibson (12, p. 57) remarked:

> We can be fairly certain.....that the visual world is dependent on eye-movements and is not seen as the result of a single fixation or a momentary visual field. It must correspond, therefore, to successive patterns of excitations on the retina, united perhaps by a kind of immediate memory. These patterns will overlap one another anatomically as the eye moves, and the basis for the visual world, therefore, must be what has been called the ordinal pattern of excitation rather than the anatomical.

and, later (p. 155):

> Some theorists have believed not only that eye-movements could account for the perception of locations and distances in space but also that they might explain the perception of patterns and two-dimensional forms. The eyes might be supposed to trace the outlines of things and thereby provide cues to their shapes. But the actual records of eye-movements have never supported the theory.

In a study of factors facilitating or inhibiting perceptual closure there are, therefore, legitimate and important questions to be asked concerning the necessity or efficacy of eye-movements.

Other questions arise. To what extent is closure affected by variations in stimulus qualities---such, for example, as brightness and clarity of definition, length of exposure, angle of regard, and the like? To what extent is it affected by different perceptual expectancies, by experience with consistent and inconsistent features within the series of stimuli?

The preceding line of thought leads to the following propositions, as points of experimental departure.

1. Variations in the brightness, clarity of definition, and retinal projection of the test-items, will not significantly affect closure performance.
2. Scanning eye-movements (or successive visual fixations) are neither necessary for nor essentially contributory to perceptual closure.
3. Inconsistent or anomalous features in the run of test-items, and changes in the subjective state of perceptual expectancy, will significantly affect closure performance.

The experimental prescription is, therefore, as follows: first, the use of a class of closure items representing objects which may be deemed highly familiar to all experimental subjects; second,

employment of viewing conditions whereby the factors of eye-movements (or successive visual fixations) and time can be controlled; third, employment of experimental apparatus and experimental design of a kind permitting controlled variation of stimulus-qualities, expectancy, and the like, and facilitating the subsequent analysis of variance attributable to the experimental treatments.

CHAPTER IV

EXPERIMENTAL MATERIALS AND PROCEDURES

General. A standard type of closure material was wanted which could be presumed to be universally familiar and interesting. The human head and face commended itself. Moreover, a technique was wanting whereby the given closure-item could be presented de novo to the subject in such fashion that while he could see it clearly, in its positive state, for an ample period of time, he would be denied the opportunity of inspecting it---that is, moving his gaze over it---but would be held to one fixation point. This problem was partially solved when, recalling the phenomenon of negative after-images, the author realized that the photographic negatives of his incomplete Closure Faces would be highly incomprehensible when "burned in" with a fixation point (as the preliminary preparation for the induction of a negative after-image) but would be normally perceptible when subsequently viewed as negative after-images (being then, by virtue of the double-negative, in their photographically positive state). Black and white depictions of the human face and head were uniquely suitable for this purpose.

Informal try-out of the technique revealed some undesirable features. When the subject, following a thirty seconds "burning in" of the test-image, turned his gaze to a dull blank screen the negative after-image (typically) took a few seconds to appear, was not so

clearly defined as seemed desirable for closure purposes, tended to fade and fluctuate, and to drift about. The problem arose: how to enhance the clarity and life of the negative after-image? Blinking the eyes rapidly had this effect (as has long been known); but this was intolerable. Accordingly, flickering light was introduced during the induction phase (not during the burning-in phase). This, at a rate somewhere between two to ten cycles per second, strikingly improved the after-images, in these respects: brought it on instantly, made it vivid and clearly articulated, gave it a steady, sustained duration, and seemed to lessen its tendency to drift---this, perhaps, as a consequence of the foregoing features. Two experiments (described later) indicated the optimal flicker-rate would be about three cycles per second.

Confirming evidence for all this was subsequently found in the unique work by Miles (30) on the formation of projected visual images by intermittent retinal stimulation. Since this excellent work has been over-looked or forgotten for years, and is somewhat relevant to this present study, further attention is given to it in Appendix D.

The Closure Faces. These are reproduced in Appendix B. They were made as follows. Out of a large number of photographs of human heads and faces clipped from illustrated magazines those were selected which revealed parts of the head and the features in markedly contrasting high-lights and shadows. From these, hand-drawings were made, copying off only the high-lights or the shadows in pure blacks and whites. The result was a series of incomplete or fragmentary pictures of people

which, however, when "seen", strikingly resembled their particular originals. Of eighty drawings made in this fashion, thirty were subsequently discarded as too easy or difficult to see, poorly drawn, ambiguous, and the like. In addition to these fifty real faces twenty false pictures were made; in terms of the graphic "stuff" they looked very much like the others but were not based on anything and could only be construed as faces of real people by a projective stretch of the imagination. The seventy pictures were then reproduced in both positive and negative form on 35 mm. slides using Kodak Microfile film to ensure perfect reproduction when projected onto a screen.

The Closure Letters and Words. These are illustrated in Appendix C. They are incomplete representations, in block-letter form, of letters of the alphabet, and of simple three- and four-letter words. They were hand-drawn in India ink on transparent acetate paper and mounted between glass to make 35 mm. slides suitable for projection in the same fashion as the Closure Faces.

The Projecting Apparatus. This is described in detail in Appendix A. It comprised a 500 watt slide projector with a light-interrupter in front of it driven by a variable speed motor; the light, and the images projected on the screen could be flickered, with a light-dark-ratio of 50:50, at any desired rate up to 70 cycles per second. One ancillary piece of apparatus permitted a high-pitched musical tone to be delivered to the subject through ear-phones, production of the tone being

synchronized with the light, so that flickering sound could be delivered simultaneously with flickering light. Another ancillary piece of apparatus permitted five out of six of the light flashes being delivered by the flicker apparatus to be blocked out; this provided tachistoscopic control and permitted one or more successive exposures to be made at any desired exposure speed. The apparatus was designed to be noiseless; what little noise it made was unobtrusive and attributable mainly to the hum of the cooling fan in the projector.

The Testing Situation. The projecting apparatus was on one side of a partition, the subject seated on the other side. The viewing screens were large rectangles of white or black matte cardboard with low reflectance; sometimes a white Radiant pebbled screen was used. The screens were on a wall eight feet distant from the projector lens and took a screen image (of the test item) 20 by 30 inches. The subject was seated in a chair four feet from the screen and about 25 degrees off center. A second screen, to the right of the viewing screen, was directly in front of the subject. An arm-rest on the right of the chair held a toggle switch which the subject could push forward and back, turning on and off a small light beside the projecting apparatus, visible only to the experimenter. The projecting apparatus, as well as the surrounding walls and the partition were covered with black cloth or black cardboard shields to damp stray light. The testing room itself was windowless and sound-proof. The slides used in each particular

experiment were laid out on a table-top alongside the apparatus, arranged according to their appearance in the experimental design, so that the experimenter could proceed swiftly through the test series.

The Testing Procedure. This entailed, invariably, (since the experiments were so designed) one hour, approximately, per subject. The subject was seated and a sample item projected on the screen. The experimenter explained exactly how the pictures were made; that while in the first moments a given picture might look meaningless, it would presently organize itself or snap together into a sensible and comprehensible picture of a real person's head or face; that this was a phenomenon called closure; that when this closure occurred the subject would be able to describe the person; that he could do so in such terms as, first, the sex; second, the approximate age; third, the presentation or orientation of the head; and fourth, any other aspects he noted--- expression, eyes open or closed, and similar details. All this was illustrated with reference to the example showing on the screen. A further easy item was given to rehearse the subject in the procedure. The ten minutes so employed enabled the subject's eyes to become adapted to the darkened room. The subject was assured that after the test session he would be free to ask the experimenter any questions he wished and to examine the apparatus.

The procedure in inducing negative after-images was this. A black ring on a white ground, a white disc on a black ground, and similar simple geometric designs were used to acquaint the subject with

the after-image phenomenon. The subject was instructed to stare steadily at a designated central fixation point on the projected pattern for thirty seconds and then, on the signal "now", to switch his gaze to an imaginary fixation point on the middle of a second viewing screen right beside the fixation screen and to keep his eyes quite steady. The original image, meanwhile, continued to be projected on the first screen. After a few seconds the subject was able to report and describe the negative after-image. On the next practice example, he was told that everything would be the same except that on the signal "now" the light on the first screen (involving the test-image) would start to flicker on and off at a rate of three cycles per second, but that he was to pay no attention to this, not to look back, and to concentrate on staring at and holding steady (by not moving his eyes at all or trying to scan) the resulting after-image. This came on vividly at once, was very clearly defined, and easier to hold steady on the screen. This flicker procedure was then used with a sample Closure Face, and the subject was given practice in using the toggle switch, describing the kind of person thus perceived and the like. In running a series of Closure Faces through the after-image treatment, a fixation point, approximately in the center of each picture was pointed out by the experimenter. The same fixation point, with each picture, was used throughout all experiments.

In the tachistoscopic representations, a dim rectangle of light was intermittently flashed on the screen between exposures of the test-item; it was in the same place and of the same size as the test-item

image, and its central area was fixated by the subject in anticipating the imminent exposure of the test-item.

The Response Criteria. The experimenter's problem was to know that the subject had seen the face implied by the incomplete representation. In most instances this was easily ascertained, there being several points of verification---the sex, approximate age, the way the head was facing or turned or held, whether all of the head was visible or whether the face was close up to the frame, the expression, and the like, most of which could be brought out in non-directive cross-examination by the experimenter, when necessary; in instances of real doubt the subject was asked to go to the screen and point to the location of eyes, mouth, brow, and so on. Not all of these, especially sex and age, were reliable indices; but, taken together, a sufficient "weight of evidence" could be elicited to "prove" the perception. Two minor difficulties in crediting an item as seen or not seen or wrongly seen were, first, inarticulateness or reticence on the part of some subjects, and second, the impoverished visualization generally characteristic of those who were "poor" at closure. In all instances of reasonable doubt, the experimenter credited the subject with a score.

The Experimental Designs. Since the experiments were concerned with over-all effects of variations in stimulus qualities, viewing conditions, perceptual expectancies, and the like, the preferred analytical technique was that of the analysis of variance. Since a major source of variance was bound to be that attributable to individual differences in closure

facility, it was necessary to use a relatively large number of subjects (two to three dozen) in each experiment, and to inter-change these among experimental "cells" in order to depress this source of variance. To enhance the reliability of results, because of this same feature, it was necessary to secure several readings for each subject (anywhere from eight to a dozen) for each experimental variation. It seemed desirable, further, to have subjects serve as their own controls, not simply because this further ensured the reliability of results but because it meant economy in subjects---a desirable feature, since a subject once used could not again be used in any other experiment entailing the same test-items. An order effect was introduced, therefore, which had to be experimentally controlled. Accordingly, all designs were based on a Graeco-Latin Square where experimental treatments, item-groups, and the like, were so ordered that each appeared equally often in each row and column of the design.

In striking F-ratios to test significance, the "within cells" variance---whenever obtained---was taken as the appropriate denominator (being construed as independent random error). This was adequate in those experiments where the design was replicated to provide two or three persons per "cell". In such, the last-order interaction variance was in essence, "between cells" variance---attributable to individual differences, but so "ironed out" by the nature of the design and the replicative feature, that it was seldom significant. Where the last-order interaction was significant, the rationale of the experiment determined whether it or the "within cells" variance should apply in the tests of significance.

The Experimental Subjects. A closure item once seen is thereafter seen; because of this feature, subjects are expendable. In the present experiments a large number of subjects was required, and it was desirable that they come from one "population". Therefore, except in the first preliminary experiments, all subjects were drawn from the undergraduate population of one university. They ranged in age from 18 to 35, with a mean age of 20 years. They were selected at random for the various experiments. One hundred and seventy were involved. In the preliminary experiments, ninety-five subjects (origins specifically noted in these experiments) were utilized. In all, 265 subjects were used.

CHAPTER V

EXPERIMENTS AND FINDINGS

Twelve experiments are reported here. Basic procedures were standard (vide Chapter IV); accordingly, repetitious detail has been omitted. Each report has three parts---the purpose, procedure, and findings. Summary and discussion are reserved for Chapter VI.

The experiments are designated and located as follows:

Experiment I : Optimal Flicker-Rate for Enhancing Negative After-Images..... p. 44

Experiment II : The Flicker Condition as a Factor in Closure..... p. 51

Experiment III : Closure under the Three Viewing Conditions..... p. 57

Experiment IV : Closure at Different Tachistoscopic Speeds..... p. 66

Experiment V : Closure with Incomplete Words at Different Tachistoscopic Speeds.... p. 71

Experiment VI : Brightness and Clarity as Factors in Closure with Faces..... p. 76

Experiment VII : Brightness and Clarity as Factors in Closure with Letters..... p. 82

Experiment VIII: Closure with Central and Peripheral Fixations..... p. 85

Experiment IX : Closure on One and Two Tachistoscopic Exposures..... p. 90

Experiment X : Closure with After-Images under Flickering Light and Sound..... p. 92

Experiment XI : Perceptual Expectancy as a Factor in Closure..... p.103

Experiment XII : Closure with Item-Negatives..... p.113

EXPERIMENT I

OPTIMAL FLICKER-RATE FOR ENHANCING NEGATIVE AFTER-IMAGES

Purpose. It was desired to optimize the clarity and duration of the Closure Faces when presented as negative after-images. Blinking the eyes rapidly seemed to have this effect. Since this was intolerable, a flickering light was substituted; this appeared remarkably effective at somewhere between two and ten cycles per second. Accordingly, the optimal flicker-rate had to be determined.

Procedure. A variable speed motor drove a light-interrupter (a sectored disk) to produce a light-dark ratio (LDR) of 50:50. A 35 mm. slide projector (250 watts) behind the interrupter projected the stimulus on a semi-opaque screen (6"x10") fitted in the front of a large black box (33"x49"x67") within which a subject was seated. The projected stimulus entirely filled the area of the screen. A push/push (on/off) switch, employed by the subject, operated an electric timer. The stimulus slides were (1) a black ring on a white background, with a small black dot as fixation point in the centre, and (2) two concentric black rings surrounding a black disk, on a white background, with a small white dot as fixation point in the centre. Slide (1) was used to instruct subjects; slide (2) was employed in the experimental tests.

Subjects were first practised in fixating the image for thirty seconds and then seeing the negative after-image on the screen after the image was removed and the screen illuminated with a faint, steady light. At the same time the motor was turned on with a 0-setting

to accustom them to its sound. They were also given practice in operating the timer-switch at the onset of the after-image and at the moment it first disappeared. They were advised that during the subsequent experimental session they would be seeing the after-images in some instances under plain, steady light, and in other instances under intermittent flickering light, but that in all instances they would push the switch when the after-image first appeared and push it again when it first disappeared.

The experiment was done first with ten subjects (3 adult males and 7 adult females), and repeated with another ten subjects (young flight cadets). Six flicker-rates were used, randomly ordered for each subject, namely: 0.0, 2.5, 5.0, 10.0, 12.5, and 15.5 cycles per second. At least half an hour elapsed between each such trial. The subject's score for each trial was the time in seconds from the moment he first pushed the timer switch until the second time he pushed it, being the initial duration of the negative after-image.

Findings. The readings are summarized in Tables I-1 and I-2, and their significance, by analysis of variance, is shown in Tables I-3 and I-4. The negative after-images were significantly more persistent at a flicker-rate between 2.5 and 5.0 cycles per second.

It could only be assumed at this point, that a flicker-rate of, say, 3.0 cycles per second might result in a more vivid after-image. Subjects so reported. It was decided that this point might be resolved later, in subsequent experiments entailing closure scores, based on negative after-images under conditions of non-flicker in comparison with

flicker. It also seemed that the present apparatus and procedure was unnecessarily cumbersome and complicated, hence, a simpler apparatus and procedure was subsequently adopted (described in Chapter IV).

TABLE I-1

INITIAL DURATION OF NEGATIVE AFTER-IMAGES IN SECONDS
FOR TEN ADULTS UNDER SIX DIFFERENT FLICKER FREQUENCIES

	Flicker-rates per second					
Subjects	0.0	2.5	5.0	10.0	12.5	15.5
1	2.50	7.00	9.50	2.25	5.50	2.50
2	1.00	9.00	4.00	2.50	2.00	2.75
3	3.75	9.00	1.25	7.00	2.75	8.00
4	8.00	6.50	3.75	2.25	3.25	2.00
5	6.00	16.00	9.00	9.00	5.50	8.75
6	4.50	7.75	3.75	2.50	2.50	1.50
7	5.75	9.75	7.50	4.75	7.25	10.00
8	8.50	3.25	7.75	6.75	4.00	1.50
9	6.75	10.00	6.50	2.50	1.25	1.00
10	7.75	7.25	27.50	11.00	6.50	8.75
	54.50	85.50	80.50	50.50	40.50	46.75

TABLE I-2

INITIAL DURATION OF NEGATIVE AFTER-IMAGES IN SECONDS FOR TEN YOUTHS UNDER SIX DIFFERENT FLICKER FREQUENCIES AFTER 30-SECOND FIXATIONS

	Flicker-rates per second					
Subjects	0.0	2.5	5.0	10.0	12.5	15.5
1	6.40	17.50	12.00	6.50	4.60	2.10
2	5.50	9.20	17.50	5.30	7.60	4.50
3	7.70	11.50	10.00	8.00	6.30	8.00
4	4.30	7.50	7.50	1.50	2.30	1.40
5	4.20	14.50	7.40	11.00	6.80	10.25
6	8.50	10.00	15.30	6.90	10.00	11.00
7	6.20	8.30	4.50	5.50	7.00	5.50
8	2.50	3.00	7.00	1.30	2.70	1.30
9	5.00	8.60	19.10	8.20	6.00	7.70
10	9.90	19.90	13.50	8.50	11.00	8.50
Total	60.20	110.00	113.80	62.70	64.30	60.25

TABLE I-3

ANALYSIS OF VARIANCE OF DURATIONS OF NEGATIVE AFTER-IMAGES (ADULTS)

Source	df	SS	MS	F	p
Subjects	9	356.15	39.57	3.35	(.01=2.83)
Flicker rates	5	174.63	34.93	2.96	(.05=2.43)
Remainder	45	531.61	11.81		
Total	59	1062.39			

TABLE I-4

ANALYSIS OF VARIANCE OF DURATIONS OF NEGATIVE AFTER-IMAGES (YOUTHS)

Source	df	SS	MS	F	p
Subjects	9	340.94	37.88	4.08	(.01=2.83)
Flicker Rates	5	335.76	67.15	7.23	(.01=3.46)
Remainder	45	417.99	9.29		
Total	59	1094.69			

EXPERIMENT II

THE FLICKER CONDITION AS A FACTOR IN CLOSURE

Purpose. Two initial questions required an answer---first, would the selected flicker-rate of three cycles per second itself facilitate perception of the Closure Faces? and, second, would the prescribed thirty-second inspection of the photographic negatives of the Closure Faces (prelude to the induction of the negative after-image) confer any perceptual advantage?

Procedure. An analysis of variance design was employed, based on a 4 x 4 x 4 Graeco-Latin Square, shown in Table II-1. The variables were ITEMS, TREATMENTS, and ORDER. The difficulty-values of the Closure Faces were unknown; the 48 selected for the experiment were simply sorted into four piles of 12 each (Table II-2). The four TREATMENTS were: T-1---direct (free) inspection of the original (positive) item; T-2---direct inspection of the original under light flickering at three cycles per second; T-3---direct (free) inspection of the original following a thirty-second observation of its photographic negative with the eye held on a prescribed central fixation point; T-4---observation of the negative after-image following the same preliminary preparation employed in T-3.

The subjects were 48 randomly selected male inmates of an Ontario prison reformatory. Their age-range was 15 to 25, with a mean age of 19 years. Their educational grade-range was 6 to 10, the

modal grade being 8. Their intelligence score-range was 76 to 124, with a mean of 99 (based on the Otis Beta Test: Form B).

The apparatus and procedures are described in detail in Chapter IV.

Findings. The analysis of variance is shown in Table II-3. There were no significant differences between treatments T-1, T-2, and T-3; but treatment T-4 differed significantly from these, as shown in Table II-4. It could be concluded, therefore, that the flicker was not a factor in itself in facilitating the closures; and that preliminary thirty-second fixation of the photographic negatives did not confer any perceptual advantage in subsequently closing on the positives, seen either directly, or in the form of negative after-images.

TABLE II-1

GRAECO-LATIN SQUARE DESIGN EMPLOYED IN EXPERIMENT NO. II

	Order of Treatments and Item Groups			
Subjects	First	Second	Third	Fourth
1 17 33	T-1 I-1	T-2 I-2	T-3 I-3	T-4 I-4
2 18 34	T-1 I-4	T-2 I-1	T-3 I-2	T-4 I-3
3 19 35	T-1 I-3	T-2 I-4	T-3 I-1	T-4 I-2
4 20 36	T-1 I-2	T-2 I-3	T-3 I-4	T-4 I-1
5 21 37	T-2 I-1	T-1 I-2	T-4 I-3	T-3 I-4
6 22 38	T-2 I-4	T-1 I-1	T-4 I-2	T-3 I-3
7 23 39	T-2 I-3	T-1 I-4	T-4 I-1	T-3 I-2
8 24 40	T-2 I-2	T-1 I-3	T-4 I-4	T-3 I-1
9 25 41	T-3 I-1	T-4 I-2	T-1 I-3	T-2 I-4
10 26 42	T-3 I-4	T-4 I-1	T-1 I-2	T-2 I-3
11 27 43	T-3 I-3	T-4 I-4	T-1 I-1	T-2 I-2
12 28 44	T-3 I-2	T-4 I-3	T-1 I-4	T-2 I-1
13 29 45	T-4 I-1	T-3 I-2	T-2 I-3	T-1 I-4
14 30 46	T-4 I-4	T-3 I-1	T-2 I-2	T-1 I-3
15 31 47	T-4 I-3	T-3 I-4	T-2 I-1	T-1 I-2
16 32 48	T-4 I-2	T-3 I-3	T-2 I-4	T-1 I-1

TABLE II-2

GROUPING OF TEST-ITEMS ACCORDING TO ORDER OF PRESENTATION

Item Groups	Items											
I-1	1	8	9	16	17	24	25	32	33	40	41	48
I-2	2	7	10	15	18	23	26	31	34	39	42	47
I-3	3	6	11	14	19	22	27	30	35	38	43	46
I-4	4	5	12	13	20	21	28	29	36	37	44	45

TABLE II-3

ANALYSIS OF VARIANCE DUE TO DIFFERENT ITEMS, TREATMENTS, ORDER

Source	df	SS	MS	F	p
Item Groups (I)	3	52.64	17.55	---	
Treatments (T)	3	270.22	90.07	11.91	(.001 = 5.79)
Order (O)	3	14.01	4.67	---	
Interactions					
I x T	9	77.68	8.63	---	
O x T	9	163.14	18.13	---	
I x O	9	82.05	9.12	---	
Triple Interaction	27	141.88	5.25	---	
Within Cells	128	968.00	7.56		
Total	191	1769.62			

TABLE II-4

SCORES BY TREATMENTS AND ORDER

	Treatments				
Order	T-1	T-2	T-3	T-4	Total
First	94	110	93	52	349
Second	108	93	90	73	364
Third	99	91	93	88	371
Fourth	89	121	118	57	385
Total	390	415	394	270	1469

EXPERIMENT III

CLOSURE UNDER THE THREE VIEWING CONDITIONS

Purpose. This was to compare perception of the Closure Faces under the three different viewing conditions---namely: direct inspection of the original (positive) pictures, with the eyes free to move, and ample time allowed; tachistoscopic presentation of the original pictures, at a speed permitting only one visual fixation; and presentation of the positive pictures---in the state of negative after-images ---with the eyes held to one fixation point but with ample time for viewing. It seemed desirable, at the same time, to compare perception of the real faces with perception of the non-real, under these same conditions.

Procedure. An analysis of variance design was employed, based on a 3 x 3 x 3 Graeco-Latin Square, shown in Table III-1. The variables were TREATMENTS, ITEMS, and ORDER. The three TREATMENTS were: T-1---direct inspection of the positive item, for up to 30 seconds; T-2---tachistoscopic observation of the positive item, at a 1/12 second exposure where, if the item was not perceived on one exposure, two successive exposures---at an 11/12 second interval---were given, and, if not then seen, three successive exposures (as a limit)---at 11/12 second intervals---were given; T-3--- inspection of the negative after-image (this being, in the photographic sense, the item in its original or positive state) for up to 30 seconds. Since the difficulty-values of the Closure Faces were not known, the 36

real ones and the 18 false ones were respectively sorted at random into three item piles (each pile of 18 comprising 12 real and 6 false). This sorting is shown in Table III-2.

The subjects were 27 randomly selected adults from the staff of a medical research establishment (comprising 10 scientists and 17 administrative personnel, of which 7 were females and 20 males, with an age-range of 18 to 43, and a mean age of 30).

Subjects were told that all items were real faces.

The apparatus and procedures are described in detail in Chapter IV.

Findings. Two analyses of variance, for the real faces seen, and for the false faces "seen", are shown in Tables III-3 and III-4. Their correlation is shown in Table III-5. The breakdown of scores, for significant variables, is given in Tables III-6 and III-7.

For the real faces, performance did not differ between Treatment 1 (direct inspection) and Treatment 3 (negative after-images), but was significantly ($p. = .05$) superior under Treatment 2 (tachistoscopic). There was a significant increase in performance over successive item-groups. With the false faces, there was no difference between Treatments 2 and 3; but under Treatment 1 significantly fewer of the false faces were erroneously "seen". There was no change with successive item-groups.

In all, 73 percent of the real faces were correctly seen, and 38 percent of the false faces were erroneously "seen".

Of perceptions under Treatment 2 (tachistoscopic) 48 percent were accomplished on the single exposure, 39 percent on the

double exposure, and 13 percent on the triple exposure. Of the misperceptions, 13 percent were accomplished on the single exposure, 38 percent on the double, and 49 percent on the triple.

TABLE III-I

GRAECO-LATIN SQUARE DESIGN EMPLOYED IN EXPERIMENT NO. III

	Order of Treatments and Item Groups		
Subjects	First	Second	Third
1 10 19	T-1 1-1	T-2 1-2	T-3 1-3
2 11 20	T-1 1-2	T-2 1-3	T-3 1-1
3 12 21	T-1 1-3	T-2 1-1	T-3 1-2
4 13 22	T-2 1-1	T-3 1-2	T-1 1-3
5 14 23	T-2 1-2	T-3 1-3	T-1 1-1
6 15 24	T-2 1-3	T-3 1-1	T-1 1-2
7 16 25	T-3 1-1	T-1 1-2	T-2 1-3
8 17 26	T-3 1-2	T-1 1-3	T-2 1-1
9 18 27	T-3 1-3	T-1 1-1	T-2 1-2

TABLE III-2

GROUPING OF TEST-ITEMS ACCORDING TO ORDER OF PRESENTATION

Item Groups	Items*								
I-1	1	(52)	2	(3)	5	6	8	(19)	9
	10	11	(29)	12	13	14	(4)	15	(60)
I-2	(30)	16	17	(45)	(21)	18	22	23	24
	25	(59)	26	27	28	32	(44)	33	(64)
I-3	(41)	34	35	36	(20)	(48)	37	39	46
	49	51	(63)	62	67	(58)	69	(43)	70

*False items in brackets.

TABLE III-3

ANALYSIS OF VARIANCE FOR REAL FACES SEEN

Source	df	SS	MS	F	p
Item Groups (I)	2	46.22	23.11	5.52	(.01 = 5.06)
(I-1 vs. I-3)	(1)	(2.67)	(2.67)	--	
(I-2 vs. $\frac{1+3}{2}$)	(1)	(43.55)	(43.55)	(10.39)	(.01 = 7.17)
Treatments (T)	2	25.41	12.71	3.03	(.05 = 3.18)
(T_1 vs. T_3)	(1)	(.90)	(.90)	--	
(T_2 vs. $\frac{1+3}{2}$)	(1)	(24.51)	(24.51)	(5.85)	(.05 = 4.03)
Order (O)	2	33.56	16.78	4.00	(.05 = 3.18)
(O_1 vs. O_2)	(1)	(4.18)	(4.18)	--	
(O_3 vs. $\frac{1+2}{2}$)	(1)	(29.38)	(29.38)	(7.01)	(.01 = 7.17)
Interactions					
I x T	4	30.37	7.59	--	
I x O	4	27.57	6.89	--	
T x O	4	50.37	12.59	3.00	(.05 = 2.56)
Triple Interaction	8	18.06	2.26	--	
Within Cells	54	226.00	4.19		
Total	80	457.56			

TABLE III-4

ANALYSIS OF VARIANCE FOR FALSE FACES "SEEN"

Source	df	SS	MS	F	p
Item Groups (I)	2	21.51	10.76	5.33	(.01 = 5.06)
(I-1 vs. I-3)	1	(.02)	(.02)	--	
(I-2 vs. $\frac{1+3}{2}$)	1	(21.48)	(21.48)	(10.63)	(.01 = 7.17)
Treatments (T)	2	14.99	7.50	3.71	(.05 = 3.18)
(T-2 vs. T-3)	1	(.17)	(.17)	--	
(T-1 vs. $\frac{2+3}{2}$)	1	(14.82)	(14.82)	(7.34)	(.01 = 7.17)
Order (O)	2	2.69	1.35	--	
Interactions					
I x T	4	10.41	2.60	--	
I x O	4	14.71	3.68	--	
O x T	4	3.46	.87	--	
Triple Interaction	8	10.93	1.37	--	
Within Cells	54	109.33	2.02		
Total	80	188.03			

TABLE III-5

RELATIONSHIP BETWEEN PERCEPTION OF REAL FACES AND FALSE

Source	df	SS Real Faces	S Products	SS Non-Real	r
Item Groups (I)	2	46.22	30.82	21.51	.977
Treatments (T)	2	25.41	14.26	14.99	.731
Order (O)	2	33.56	-6.70	2.69	-.705
Interactions					
I x T	4	30.37	10.08	10.41	.566
I x O	4	27.57	19.25	14.71	.956
T x O	4	50.37	-6.97	3.46	-.528
Triple Interaction	8	18.06	4.63	10.93	.330
Within Cells	54	226.00	47.33	109.33	.441
	80	457.56	112.70	188.03	.384

TABLE III-6

SCORES BY TREATMENTS AND ORDER

	Treatments							
	Real Faces				False Faces			
Order	T-1	T-2	T-3	Total	T-1	T-2	T-3	Total
1st	74	83	60	217	12	25	25	62
2nd	61	88	83	232	19	26	22	67
3rd	87	86	86	259	14	20	21	55
Total	222	257	229	708	45	71	68	184

TABLE III-7

SCORES BY TREATMENTS AND ORDER

	Item Groups							
	Real Faces				False Faces			
Order	I-1	I-2	I-3	Total	I-1	I-2	I-3	Total
1st	72	88	57	217	18	32	12	62
2nd	70	88	74	232	15	30	22	67
3rd	86	88	85	259	19	19	17	55
Total	228	264	216	708	52	81	51	184

EXPERIMENT IV

CLOSURE AT DIFFERENT TACHISTOSCOPIC SPEEDS

Purpose. This was to find out more about facility in perceiving the Closure Faces when presented tachistoscopically---specifically to assess this performance as a function of the speed of exposure, and of the number of exposures.

Procedure. An analysis of variance design was employed, based on a 3 x 3 x 3 x 3 Graeco-Latin Square, shown in Table IV-1. The three tachistoscopic speeds were S-1---1/8 second, S-2---1/16 second, and S-3---1/24 second. An item was exposed once, at the selected speed; if not perceived, it was exposed twice in succession; if not then perceived it was exposed three times in succession. The intervals between the double and triple exposures were, at S-1---11/8 seconds; at S-2---11/16 seconds; at S-3---11/24 seconds. The 36 items (real faces) were randomly sorted into three item groups of 12 each, shown in Table IV-2. With 27 subjects, the Graeco-Latin Square was replicated three times. With the three exposure conventions used, there were 81 cells, with three scores per cell, making a total of 243 measurements.

The apparatus and testing procedures are described in detail in Chapter IV.

Findings. The analysis of variance is shown in Table IV-3, and the breakdown of scores for the significant variables of exposures and order is given in Table IV-4.

Performance was not a function of the tachistoscopic speed variations employed here. The over-all accomplishment was 70 percent. There was a significant improvement in performance over successive item groups, and this was strikingly related to the number of exposures. Whereas on their first item-group subjects effected 12 percent of their closures on a single exposure and 5 percent of them on the triple exposure, on their third-item group they were effecting 24 percent of closures on the single exposure and 3 percent on the triple exposure. Disregarding order, of all closures accomplished, 57 percent were effected on one exposure, 31 on two exposures, and 12 on three.

TABLE IV-1

GRAECO-LATIN SQUARE DESIGN EMPLOYED IN EXPERIMENT IV

Order of Tachistoscopic Speeds and Item Groups.

Subjects	First	Second	Third
1 10 19	S-1 I-1	S-2 I-2	S-3 I-3
2 11 20	S-2 I-1	S-3 I-2	S-1 I-3
3 12 21	S-3 I-1	S-1 I-2	S-2 I-3
4 13 22	S-1 I-2	S-2 I-3	S-3 I-1
5 14 23	S-2 I-2	S-3 I-3	S-1 I-1
6 15 24	S-3 I-2	S-1 I-3	S-2 I-1
7 16 25	S-1 I-3	S-2 I-1	S-3 I-2
8 17 26	S-2 I-3	S-3 I-1	S-1 I-2
9 18 27	S-3 I-3	S-1 I-1	S-1 I-2

TABLE IV-2

GROUPING OF TEST-ITEMS ACCORDING TO ORDER OF PRESENTATION

Item Groups	Items											
1-1	13	36	14	1	28	2	34	23	22	35	9	18
1-2	24	62	26	51	10	11	27	33	5	25	70	15
1-3	67	37	32	16	39	6	46	17	69	49	8	12

TABLE IV-3

ANALYSIS OF VARIANCE DUE TO TACHISTOSCOPIC SPEEDS AND EXPOSURES

Source	df	SS	MS	F	p
Item Groups (1)	2	2.03	1.02	--	
Speeds (S)	2	2.03	1.02	--	
Order (O)	2	38.62	19.31	5.09	(.01 = 4.75)
Exposures (E)	2	576.03	288.02	75.99	(.01 = 4.75)
Interactions					
1 x S	4	15.33	3.83	--	
1 x O	4	4.00	1.00	--	
1 x E	4	20.07	5.02	--	
S x O	4	28.15	7.04	--	
S x E	4	23.26	5.82	--	
O x E	4	94.22	23.56	6.22	(.01 = 3.44)
Remainder	48	235.50	4.91	--	
Within Cells	162	614.67	3.79		
Total	242	1653.91			

TABLE IV-4

SCORES BY EXPOSURES AND ORDER

Exposures	Order First	Second	Third	Total
Single	85	137	166	388
Double	62	76	72	210
Triple	36	27	21	84
Total	183	240	259	682

EXPERIMENT V

CLOSURE WITH INCOMPLETE WORDS AT DIFFERENT TACHISTOSCOPIC SPEEDS

Purpose. This was to see how perception of incomplete words compared with perception of the Closure Faces under the condition of tachistoscopic presentation (Experiment IV).

Procedure. The experiment occurred in conjunction with Experiment IV. The 36 incomplete words (illustrated in Appendix C) were randomly sorted into three item groups. Experimental design and procedure were identical except that S-1 was not tachistoscopic, but was a five-second presentation. Since the subjects participated in both Experiments IV and V at the same one-hour session, the order of experiments was alternated from subject to subject.

Findings. Two analyses of variance, one for total scores, disregarding the number of exposures, and the other for scores under Speeds 2 and 3 only, taking account of the number of exposures, are shown in Tables V-1 and V-2, respectively. The relevant breakdown of scores is given in Table V-3.

Performance did not vary significantly under the different speeds employed; the five-second exposure time was not markedly more effective than the tachistoscopic exposure speeds. The item groups differed significantly in difficulty, and performance on particular item groups was significantly related to the number of exposures. With respect to overall scores, under the three speed conditions, there was

a significant improvement in performance on successive item groups.

The over-all accomplishment was 69 percent; for the tachistoscopic conditions, only, it was 66 percent.

In terms of the number of tachistoscopic exposures required, 53 percent of the closures were effected on the single exposure, 30 percent on the double, and 17 percent on the triple. This is comparable to performance with the Closure Faces (Experiment IV) where the corresponding percentages were 57, 31, and 12.

TABLE V-1

ANALYSIS OF VARIANCE DUE TO SPEEDS, ITEM GROUPS, ORDER.

Source	df	SS	MS	F	p
Speeds	2	14.25	7.12	---	
Order	2	34.99	17.49	5.59	(.01 = 5.06)
Item Groups	2	73.65	36.82	11.76	(.01 = 5.06)
Remainder	20	98.11	4.86	---	
Within cells	54	169.06	3.13		
Total	80				

TABLE V-2

ANALYSIS OF VARIANCE DUE TO SPEEDS AND EXPOSURES

Source		df	SS	MS	F	p
Speeds	(S)	1	.39	.39	---	
Item Groups	(I)	2	23.42	11.71	4.80	(.01 = 4.82)
Order	(O)	2	8.64	4.32	---	
Exposures	(E)	2	220.45	110.27	45.19	(.01 = 4.82)
Interactions						
S x I		2	.98	.49	---	
S x O		2	.65	.33	---	
S x E		2	6.47	3.24	---	
I x O		4	6.25	1.56	---	
I x E		4	47.10	11.78	4.83	(.01 = 3.51)
O x E		4	9.55	2.39	---	
Triple Interaction						
I x O x E		8	73.90	9.24	3.79	(.01 = 2.69)
Remaining triple and quadruple interaction		20	88.84	4.44	---	
Within cells		108	264.00	2.44		
Total		161	750.64			

TABLE V-3

SCORES BY EXPOSURES AND ITEM GROUPS

Item Groups	Exposures			
	Single	Double	Triple	Total
I-1	77	32	16	125
I-2	54	44	35	133
I-3	96	52	24	172
Total	227	128	75	430

EXPERIMENT VI

BRIGHTNESS AND CLARITY AS FACTORS IN CLOSURE WITH FACES

Purpose. This was, first, to see if perception of the Closure Faces, under the condition of direct inspection, was significantly affected by changing the brightness and clarity of definition of the projected test-items, and, second, to measure the rapidity of closure.

Procedure. An analysis of variance design was employed, based on a 2 x 2 x 4 x 4 Graeco-Latin Square, shown in Table VI-1. Two TREATMENTS were: T-1---where the image was in focus; T-2---where the image was out of focus (hence, gray and foggy, with the ordinarily sharp contours between white and black patches markedly blurred). Two CONDITIONS were: C-1---in which a white matte cardboard screen was used; C-2---in which a dull black matte cardboard screen was used. The thirty-two items used were randomly sorted into four ITEM GROUPS of eight each, as shown in Table VI-2.

The screen image was 18 inches by 24, 70 inches distant from the projector lens. In the out-of-focus treatment, the image was focussed 36 inches ahead of the lens. Subjects were seated six feet from the screen, about 30 degrees off center. The reflectance of the white screen was 3.2 and that of the black .2 as measured by a Weston Universal photographic light meter.

Times, from the instant the picture was flashed on the screen, until the subject effected the closure and signalled this by

turning on a light, were measured on a stop-watch to the nearest half-second. Total time allowed per item was 30 seconds.

The sixteen subjects were young under-graduates---10 men and 6 women---with a mean age of 20 years.

The apparatus and testing procedures are described in detail in Chapter IV.

Findings. Separate analyses of variance were done for both the number of correct perceptions and the times (in seconds) for all such perceptions. These are shown in Tables VI-3 and VI-4. No effects can be attributed to either the treatments or the conditions employed. Subjects perceived the items as readily out of focus as in focus, and on a black, dull screen as on a white bright one. Table VI-5 is presented simply to show the average time in seconds required to close on an item. The average recorded time for a correct perception was four seconds. The average recorded time for an erroneous perception was 16.5 seconds. Of all items presented, 64 percent were seen correctly, 14 percent were seen incorrectly, and 22 percent were not tried.

TABLE VI-1

GRAECO-LATIN SQUARE DESIGN EMPLOYED IN EXPERIMENT NO. VII

Subjects	Order of Treatments, Conditions, Item Groups			
	First	Second	Third	Fourth
1	T-2 C-2 I-1	T-1 C-2 I-2	T-2 C-1 I-3	T-1 C-1 I-4
2	T-1 C-2 I-1	T-2 C-1 I-2	T-1 C-1 I-3	T-2 C-2 I-4
3	T-2 C-1 I-1	T-1 C-1 I-2	T-2 C-2 I-3	T-1 C-2 I-4
4	T-1 C-1 I-1	T-2 C-2 I-2	T-1 C-2 I-3	T-2 C-1 I-4
5	T-2 C-2 I-2	T-1 C-2 I-3	T-2 C-1 I-4	T-1 C-1 I-1
6	T-1 C-2 I-2	T-2 C-1 I-3	T-1 C-1 I-4	T-2 C-2 I-1
7	T-2 C-1 I-2	T-1 C-1 I-3	T-2 C-2 I-4	T-1 C-2 I-1
8	T-1 C-1 I-2	T-2 C-2 I-3	T-1 C-2 I-4	T-2 C-1 I-1
9	T-2 C-2 I-3	T-1 C-2 I-4	T-2 C-1 I-1	T-1 C-1 I-2
10	T-1 C-2 I-3	T-2 C-1 I-4	T-1 C-1 I-1	T-2 C-2 I-2
11	T-2 C-1 I-3	T-1 C-1 I-4	T-2 C-2 I-1	T-1 C-2 I-2
12	T-1 C-1 I-3	T-2 C-2 I-4	T-1 C-2 I-1	T-2 C-1 I-2
13	T-2 C-2 I-4	T-1 C-2 I-1	T-2 C-1 I-2	T-1 C-1 I-3
14	T-1 C-2 I-4	T-2 C-1 I-1	T-1 C-1 I-2	T-2 C-2 I-3
15	T-2 C-1 I-4	T-1 C-1 I-1	T-2 C-2 I-2	T-1 C-2 I-3
16	T-1 C-1 I-4	T-2 C-2 I-1	T-1 C-2 I-2	T-2 C-1 I-3

TABLE VI-2

GROUPING OF TEST-ITEMS ACCORDING TO ORDER OF PRESENTATION

Item Groups	Items							
I-1	24	34	18	67	11	23	49	7
I-2	13	10	5	39	51	33	46	70
I-3	36	15	6	8	17	16	12	14
I-4	37	26	1	22	32	62	25	69

TABLE VI-3

ANALYSIS OF VARIANCE FOR NUMBERS OF ITEMS PERCEIVED

Source	df	SS	MS	F	p
Treatments (T)	1	.39	.39	---	
Conditions (C)	1	1.26	1.26	---	
Order (O)	3	25.79	8.60	---	
Item Groups (I)	3	15.15	5.05	---	
T x C	1	.14	.14	---	
T x O	3	8.17	2.72	---	
T x I	3	3.31	1.10	---	
C x O	3	13.55	4.52	---	
C x I	3	18.19	6.06	---	
O x I	9	57.54	6.39	---	
Residual	33	125.24	3.80		
Total	63	267.73			

TABLE VI-4

ANALYSIS OF VARIANCE FOR TIMES IN SECONDS FOR ITEMS PERCEIVED

Source	df	SS	MS	F	p
Treatments (T)	1	146.26	146.26	---	
Conditions (C)	1	40.38	40.38	---	
Order (O)	3	90.49	30.16	---	
Item Groups (I)	3	108.55	36.18	---	
T x C	1	2.86	2.86	---	
T x O	3	222.99	74.33	---	
T x I	3	133.90	44.63	---	
C x O	3	139.40	46.47	---	
C x I	3	370.70	123.56	---	
O x I	9	723.20	80.35	---	
T x C x O	3	168.96	56.32	---	
T x C x I	3	68.75	22.92	---	
T x O x I	9	1189.15	132.13	---	
C x O x I	9	1445.66	160.63	---	
T x C x O x I	9	636.24	70.69	3.44	(.01 = 2.50)
Within Cells	265	5443.92	20.54	*	
Total	328	10931.41			

*Here, the third order interaction is employed in the denominator of the F-ratio to test the significance of variance. By this test, none of the other effects are found significant. The third order interaction represents a highly significant "between cells" variance. It may be due to an "individual difference" factor, since cells, in this analysis, rest on the performances of individual persons. It may be the factor of individual differences in speed of closure.

TABLE VI-5

SCORES AND TIMES (SECONDS) BY TREATMENTS, CONDITIONS, ORDER

Order	T-1	C-1	T-1	C-2	T-2	C-1	T-2	C-2	Total	Total	Mean
	n	t	n	t	n	t	n	t	n	t	
First	17	103.5	13	81.0	16	85.0	23	55.5	69	325.0	4.71
Second	14	66.5	25	69.5	17	76.5	20	94.5	76	307.0	4.04
Third	22	165.5	23	88.5	27	73.0	22	57.0	94	384.0	4.08
Fourth	25	61.0	23	117.0	22	61.5	20	50.0	90	289.5	3.22
Total	78	396.5	84	356.0	82	296.0	85	257.0	329	1305.5	3.97
Mean		5.08		4.22		3.61		3.02		3.97	

EXPERIMENT VII

BRIGHTNESS AND CLARITY AS FACTORS IN CLOSURE WITH LETTERS

Purpose. This was to see how perception of incomplete letters compared with perception of the Closure Faces as affected by the brightness and clarity of the test-items, (Experiment VI).

Procedure. The experiment occurred in conjunction with Experiment VI. The 20 incomplete block letters (illustrated in Appendix C) were randomly sorted into 4 piles of 5 items each. Experimental design and procedure were identical. Since the subjects participated in both Experiments VI and VII at the same one-hour session, the order of experiments was alternated from subject to subject.

Findings. Results, in terms of scores, are shown in Table VII-1. It is evident by inspection that the different treatments and conditions had no significant effect. Subjects performed as well on a dull as on a bright screen, with the image in focus or out of focus. The over-all accomplishment was 46 percent. Compared with the average time of 9.3 seconds for a correct perception the average time for an incorrect perception was 15.5 seconds. Of all the items, 46 percent were seen correctly, 35 percent incorrectly, and 19 percent were not tried. A direct comparison between perception of the letters with the Closure Faces (Experiment VI) is shown in Table VII-2.

TABLE VII-1

SCORES AND TIMES (SECONDS) BY TREATMENTS, CONDITIONS, ORDER

Order	BIF		BOF		WIF		WOF		T		Mean
	n	t	n	t	n	t	n	t	n	t	
First	7	59.5	10	60.5	8	113.0	8	123.0	33	356.0	10.78
Second	11	121.5	7	60.0	10	106.5	7	99.0	35	387.0	11.06
Third	6	74.0	9	112.5	11	88.5	13	83.0	39	358.0	9.18
Fourth	11	94.0	10	56.0	10	21.5	10	97.5	41	269.0	6.56
Total	35	349.0	36	289.0	39	329.5	38	402.5	148	1370.0	
Mean		9.77		8.03		8.45		10.59			9.26

TABLE VII-2

COMPARATIVE PERFORMANCE WITH FACES AND LETTERS

		Faces	Letters
Percent	Correct	64	46
	Incorrect	14	35
	Not tried	21	19
Mean Time in seconds per item	Correct	4.0	9.3
	Incorrect	16.5	15.5
	Not tried	30.0 (max.)	30.0 (max.)

EXPERIMENT VIII

CLOSURE WITH CENTRAL AND PERIPHERAL FIXATIONS

Purpose. This was to see if perception of the Closure Faces was, under the condition of tachistoscopic representation, as effective when the items were presented to the eye peripherally as when presented centrally.

Procedure. An analysis of variance design was employed based on a 2 x 2 x 2 Graeco-Latin Square, shown at Table VIII-1. Two Methods were: M-1---where the subject watched a fixation point in the centre of the projected test item; and M-2---where the subject watched, successively, fixation points at the four corners of the projected test item. The thirty-six items were randomly sorted into two Item Groups of eighteen each.

The over-all screen image of a test-item was a 20" x 30" upright rectangle. The central fixation point was at the center of the image. For the peripheral method, four fixation points were superimposed on the screen area occupied by the image, in a rectangular 12" x 16" pattern.

The subject sat four feet away from the screen at a 30° angle off-center. (The visual angle subtended by the image, in a central fixation, was, therefore, about 18 degrees). The room and the screen were completely dark except for a bright pin-point of light, at the fixation point (or four such points, for the peripheral method),

which blinked with a 1/18 second flash at 11/18 seconds intervals. The subject watched this; he was told that after it had flashed four or five times the test-item would flash on the screen once, at 1/18 second exposure; it would appear again, after four flashes of the exposure point, and would appear, similarly, a third and a fourth time; he was then to describe it, if he had perceived what it was; he was also to note and state on which exposure he had effected the closure. In the peripheral method, the procedure was the same except that the subject, starting at the upper left fixation point, switched to the upper right following the first exposure of the test-item, and similarly moved to the lower-left, then the lower-right, following the second and third exposures of the test-item. The subject was told the purpose of the experiment and invited to keep his gaze rivetted to the fixation points (and in this, he was automatically assisted---according to the later testimony of most subjects---by the blinking of the fixation points).

With 12 subjects, 6 men and 6 women, undergraduates, average age 20 years, the design was replicated three times. With scores broken down by the four exposures, there were, therefore, 32 cells, and 96 readings, in all.

Findings. The analysis of variance is shown in Table VIII-2, and an illustrative breakdown of scores in Table VIII-3. There was no significant difference between the two methods of viewing. No perceptual advantage was gained by fixating the center of the test-item,

as against fixating one or another of its corners. There was no significant difference between scores obtained on the first, second, third, or fourth exposure. It may be noted that 70.6 percent of the items were perceived.

It will be appreciated that the situation was advantageous for peripheral viewing. The black and white brightness differences were striking, and peripheral acuity would be, therefore, quite adequate to the task. Again, with the four fixation points, each of four quadrants in the figure would be given in near-central vision. A severe test would have required peripheral perception with but one fixation point, placed further off-center. The present experiment may be construed as revealing only that direct, foveal presentation of the figures is not essential for their perception, nor, in comparison with the peripheral displacements of the images employed here, especially advantageous.

TABLE VIII-1

GRAECO-LATIN SQUARE DESIGN EMPLOYED IN EXPERIMENT VIII

Subjects	Order of Methods and Item Groups: First	Second
1 5 9	I-1 M-2	I-2 M-1
2 6 10	I-2 M-2	I-1 M-1
3 7 11	I-1 M-1	I-2 M-2
4 8 12	I-2 M-1	I-1 M-2

TABLE VIII-2

ANALYSIS OF VARIANCE BETWEEN CENTRAL AND PERIPHERAL FIXATIONS

Source	df	SS	MS	F	p
Methods (M)	1	.85	.85	---	
Item Groups (I)	1	1.77	1.77	---	
Order (O)	1	8.77	8.77	---	
Exposures (E)	3	33.29	11.09	---	
M x I	1	8.76	8.76	---	
M x O	1	.84	.84	---	
M x E	3	11.28	3.76	---	
I x O	1	.09	.09	---	
I x E	3	5.69	1.90	---	
O x E	3	25.36	8.45	---	
Residual	13	146.64	11.28	---	
Within Cells	64	562.66	8.79	---	
Total	95	806.00			

TABLE VIII-3

SCORES BY EXPOSURES FOR CENTRAL AND PERIPHERAL FIXATIONS

Method	Exposures 1st	2nd	3rd	4th	Total
Peripheral	24	32	28	47	131
Central	31	45	25	39	140
Total	55	77	53	86	271

EXPERIMENT IX

CLOSURE ON ONE AND TWO TACHISTOSCOPIC EXPOSURES

Purpose. This was to see if perception of the Closure Faces with central tachistoscopic exposure of the test-items, was as efficient with two exposures as with four---entailing, therefore a comparison with findings in Experiment VIII.

Procedure. The central representation employed in Experiment VIII was employed, with a similar design, and all other elements and procedures identical except that only two exposures were given. Eight subjects were used.

Findings. The results are shown in Table IX-1. It is noted that 68 percent of the items were perceived (comparable to the 71 percent perceived in Experiment VIII) and that results were evenly divided between the first and the second exposures.

TABLE IX-1

PERCEPTIONS WITH ONE AND TWO TACHISTOSCOPIC EXPOSURES

Item Groups	Order	Exposures First	Second	Total
Group 1	1st	22	16	38
	2nd	23	25	48
Group 2	1st	24	23	47
	2nd	17	25	42
Total		86	89	175

EXPERIMENT X

CLOSURE WITH AFTER-IMAGES UNDER FLICKERING LIGHT AND SOUND

Purpose. This was to find out more about perception of the Closure Faces when presented in the state of negative after-images --- specifically, to compare performance under the condition of observation without flickering light with performance under, first, the condition of flickering light, and second, the condition of light and sound flickering simultaneously --- employing as comparative criteria the number of faces seen and, additionally, the durations of the after-images in seconds.

Procedure. An analysis of variance design was employed, based on a 3 x 3 x 3 Graeco-Latin Square, shown in Table X-1. The three variables were TREATMENTS, ITEM GROUPS, and ORDER. The three TREATMENTS were T-1 --- induction and observation of the negative after-images under steady (non-flickering) light; T-2 --- under light flickering at three cycles per second; T-3 --- under light and sound flickering simultaneously at three cycles per second. The 24 Closure Faces were randomly sorted into three item groups of eight each, as shown in Table X-2. With 27 subjects the Graeco-Latin Square was replicated three times. There were, therefore, 27 cells, with three subjects in each, making a total of 81 measurements; these were of two kinds, capable of being independently analyzed --- namely, the number of items correctly seen, and the durations in seconds of the after-

images. An additional measurement was introduced for the last 18 subjects --- namely, the time in seconds from the onset of the after-image until --- if it occurred --- the instant of closure.

The timing was done as follows: the subject's thumb and forefinger rested on a toggle-switch; he pushed this forward and back when he judged that the after-image had gone ("gone" being his own subjective standard of the decayed nature or useless state of the after-image --- as explained to, and established by, him in the preliminary practice session); this flashed on a small light in front of the experimenter and enabled him to take 2 stop-watch readings. The last 18 subjects were required, in addition, to flick the switch on and off when they "closed" on any of the items. Subjects were also required, simultaneously, to report verbally when the after-image had gone. This method of timing admitted small inaccuracies; however, complex and exact timing procedures seemed unnecessary at a stage where interest lay in broad effects.

The subjects were 27 under-graduates --- 16 men and 11 women --- with a mean age of 20 years.

The apparatus and testing procedures are described in detail in Chapter IV.

Findings. The analysis of variance for numbers of items seen is shown in Table X-3. Scores for significant variables are depicted in

Figure 2.

The analysis of variance for durations of the after-images (time from the instant the subject turned his gaze to the blank screen where he was to observe the after-image until it was gone) is shown in Table X-4. Mean times for significant variables are shown in Table X-5. The mean times for items seen and for items not seen, under the three experimental treatments, are shown in Table X-6.

Mean times, in seconds, until onset of closure in those instances where the items were seen (from the instant of turning the eyes to the blank viewing-screen) are shown in Table X-7.

Perceptual performance was markedly superior under Treatments 2 and 3 (flickering light, and flickering sound and light) than under Treatment 1 (steady light). The addition of sound flickering simultaneously with the light (T-3) had no effect. There was a moderate, and probably significant, increase in performance over successive item groups. There was a significant interaction between Treatments, Item Groups, and Order; this was the "between cells" variance, presumably attributable to the "fall" of trios among cells.

The "life" of the after-image, measured from the moment the eyes shifted to the viewing-screen, was not a function of the treatments, nor of experience with successive item groups. (It must be pointed out, however, that while the after-image appeared at once

under the condition of flicker, it did not appear until a few seconds after the eyes shifted to the viewing screen, under the condition of steady light; the "life" of the after-image under Treatment 1 was less, therefore, than under the other two treatments; this aspect is dealt with in a supplementary note, below.) There was no significant difference in the durations of the after-images for items seen compared to items not seen.

There was a marked difference in the time, following fixation of the viewing screen, taken to effect the closures --- ten seconds, under Treatment 1 compared to five seconds, under Treatments 2 and 3.

The finding of main interest was that 75 percent of the items were seen under the condition of flicker and only 50 percent were seen under steady light.

Supplementary Note. To check on the question of the time required for the appearance of the negative after-image under Treatment 1 (steady light), the following supplementary study was done. Eight additional subjects were each tested under Treatments 1 and 2, employing two item-groups of ten items each - the combination and order of treatments and item-groups being systematically balanced. Subjects signalled the appearance of the after-image, under Treatment 1 (steady light), and its disappearance under both treatments.

The mean time for the appearance of the after-image was

7.4 seconds. The mean duration, in seconds, for the after-image, from its appearance until its disappearance was, for Treatment 1 - 38.6 seconds, and for Treatment 2 - 38.2 seconds.

This result is surprising, and the question of the duration of the negative after-image under the two conditions of steady light and flickering light remains unresolved. There is no doubt at all that a few seconds elapse before the onset of the negative after-image under the condition of steady light, and that it comes on at once under flicker. Experiment I and, evidently, Experiment X indicate that the duration of the after-image is less, on the average, under direct light than with flicker; but this was not verified in the present supplementary study. The great variability between subjects, under the different viewing conditions, suggests that numerous readings with a large number of subjects under much more exacting methods of measurement than those employed in the present investigation would be required to specify parameters for the onset of the after-image, and its duration, under direct light and under different flicker ratios and rates.

TABLE X-1

GRAECO-LATIN SQUARE DESIGN EMPLOYED IN EXPERIMENT NO. X

	Order of Treatments and Item Groups		
Subjects	First	Second	Third
1 10 19	T-2 I-1	T-1 I-2	T-3 I-3
2 11 20	T-1 I-1	T-3 I-2	T-2 I-3
3 12 21	T-3 I-1	T-2 I-2	T-1 I-3
4 13 22	T-2 I-2	T-1 I-3	T-3 I-1
5 14 23	T-1 I-2	T-3 I-3	T-2 I-1
6 15 24	T-3 I-2	T-2 I-3	T-1 I-1
7 16 25	T-2 I-3	T-1 I-1	T-3 I-2
8 17 26	T-1 I-3	T-3 I-1	T-2 I-2
9 18 27	T-3 I-3	T-2 I-1	T-1 I-2

TABLE X-2

GROUPING OF TEST-ITEMS ACCORDING TO ORDER OF PRESENTATION

Item Groups	Items							
I-1	24	13	1	34	67	51	23	22
I-2	32	62	10	11	33	5	25	69
I-3	14	18	12	16	39	6	8	17

TABLE X-3

ANALYSIS OF VARIANCE FOR ITEMS SEEN

Source	df	SS	MS	F*	p
Treatments (T)	2	46.89	23.45	10.28	(.001=7.76)
Item Groups (I)	2	2.30	1.15	---	
Order (O)	2	15.63	7.82	3.43	(.05=3.15)
Interactions					
T x I	4	14.58	3.65	---	
T x O	4	6.81	1.70	---	
I x O	4	6.95	1.74	---	
Triple Interaction	8	95.51	11.94	5.24	(.001=3.87)
Within Cells	54	123.33	2.28	*	
Total	80	312.00			

* While the triple interaction variance is highly significant, it would not be appropriate for testing the significance of the main effects. The logic appears to be that advanced by Wert, Neidt, and Ahmann (46, p. 196 and p. 201) and by Johnson (19 , pp. 280-284). Basis for the present triple interaction variance seems to be the chance fall of scores to the cells, as engendered by the experimental design.

TABLE X-4

ANALYSIS OF VARIANCE FOR DURATIONS OF AFTER-IMAGES

Source	df	SS	MS	F	p
Treatments (T)	2	1.850	.925	---	
Item Groups (I)	2	.483	.241	---	
Order (O)	2	1.913	.957	---	
Interactions					
T x I	4	89.425	22.356	3.44	(.01=3.65)
T x O	4	62.904	15.726	2.42	(.05=2.37)
I x O	4	30.682	7.671	---	
Triple Interaction	8	6.355	.794	---	
Within Cells	54	350.818	6.497		
Total	80	544.430			

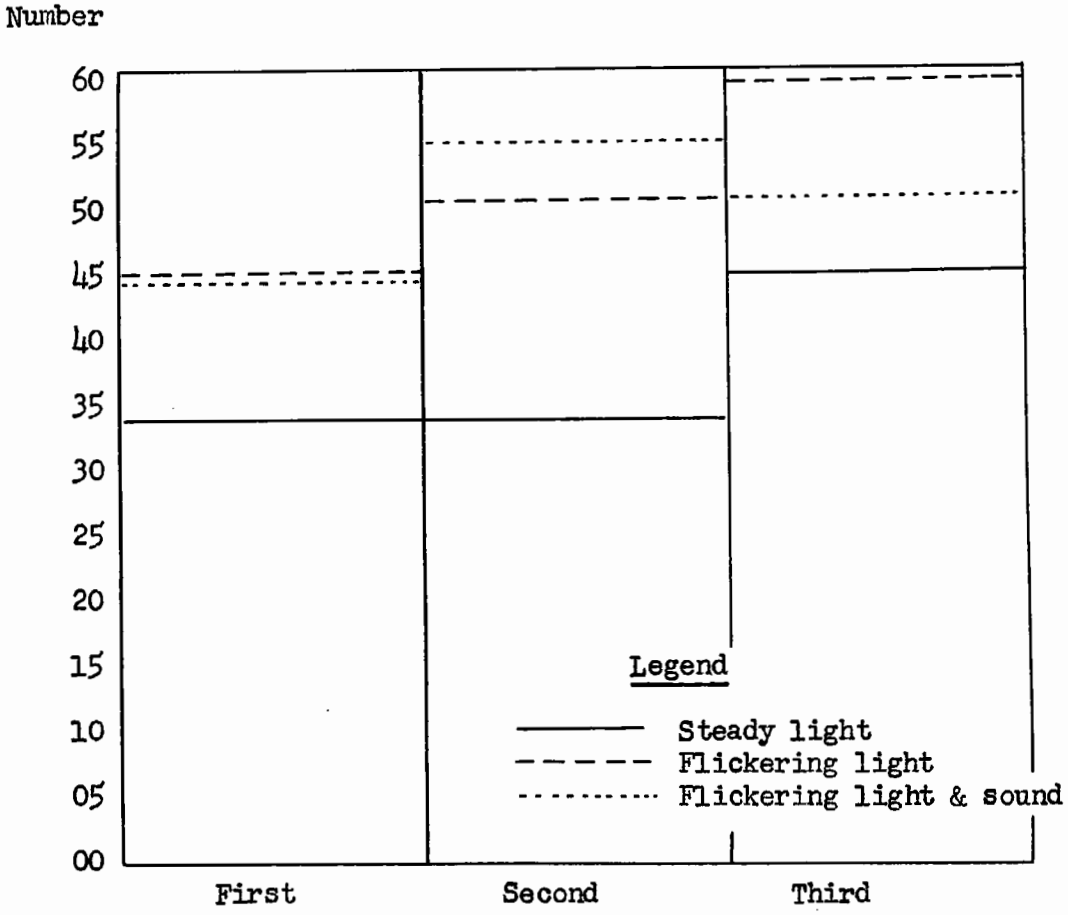


FIGURE 2 Closures Effected with Negative After-Images under Three Different Viewing Conditions with Successive Item Groups by Their Order of Presentation

TABLE X-5

MEAN DURATIONS IN SECONDS FOR ALL AFTER-IMAGES

Item Groups	Treatments Steady Light	Flickering Light	Flickering Light & Sound	Total
Group 1	46.2	24.1	36.1	35.4
Group 2	26.5	35.8	45.8	36.1
Group 3	37.7	43.4	27.0	36.1
Total	36.8	34.4	36.3	35.8

TABLE X-6

MEAN DURATIONS IN SECONDS FOR AFTER-IMAGES SEEN AND NOT SEEN

Items	Treatments Steady Light	Flickering Light	Flickering Light & Sound	Total
Seen	40.4	34.9	37.4	37.3
Not Seen	33.1	33.3	33.9	33.4
Total	36.8	34.4	36.3	35.8

TABLE X-7

MEAN TIME IN SECONDS UNTIL ONSET OF CLOSURE

Order	Treatments: Steady Light	Flickering Light	Flickering Light & Sound	Total
First	11.0	4.8	5.8	6.6
Second	10.6	4.6	6.0	6.7
Third	8.4	5.2	3.8	5.5
Total	9.8	4.9	5.1	6.2

EXPERIMENT XI

PERCEPTUAL EXPECTANCY AS A FACTOR IN CLOSURE

Purpose. This was to see to what extent perception of the Closure Faces was affected by a changed expectancy on the part of subjects, and to note this under three different perceptual conditions---namely: direct inspection of the positive test-item with ample time allowed for closure; tachistoscopic viewing of the item for brief periods permitting of only one fixation; and observation of the test item, in the form of a negative after-image, with one fixation, ample time being allowed for closure.

Procedure. An analysis of variance design was employed, based on a 2x3 x6x6 Graeco-Latin Square, shown in Table XI-1. Two SETS (expectancies) were: S-1---where subjects were told that during half of the test session all the test items would be real faces; S-2--- where subjects were told that during half of the test session approximately half of the test items would be real, the remainder being "duds". This idea was elaborated and explained with sample items. A given subject went through half of the test session under one set, and continued through the other half under the other set. Subjects had no knowledge of the item groupings.

The three viewing CONDITIONS were: C-1---the positive test item projected on the screen for direct inspection for a period of ten seconds; C-2---the positive item flashed tachistoscopically on the screen at a speed of 1/20 second, for single, double or triple exposures (11/12 seconds apart), as required for closure; C-3---induction of the test-item, in positive state, as a negative after-image, as a consequence of

"burning in" the photographic negative of the item by having the subject stare at a designated central fixation point on it for a period of thirty seconds.

Six ITEM GROUPS were composed as follows: I-1---8 real faces; I-2---8 real faces; I-3---4 real faces and 4 false; I-4---4 real faces and 4 false; I-5---8 falses faces; I-6---8 false faces. Items were sorted into groups at random, as shown in Table XI-2.

Times, in half seconds, were recorded from the instant the item was projected until the instant of closure.

Thirty-six subjects were called for, as a minimum, by this design. The total cells in the design were, therefore, 216.

The subjects were young under-graduates, 22 men and 14 women, with a mean age of 20 years.

Details of the apparatus and procedures are given in Chapter IV.

Findings. Three analyses of variance were done. The first, shown in Table XI-3, dealt only with correct perceptions of the real items. The second, Table XI-4, dealt with nil perceptions ("don't know" or "can't see") for both real and false items. The third, Table XI-5, dealt with misperceptions (real items wrongly seen or false items "seen").

Examination of these three tables reveals that perception of the real faces was not affected by the changed perceptual expectancy, the different viewing conditions, or the different composition of the item groups. Nil perceptions, and misperceptions were, however, significantly affected by these variables. They also reveal significant interaction between Conditions and Item Groups. These main effects are shown

graphically in Figures 3 and 4.

It will be noted, first, that there is no difference between the tachistoscopic and the negative after-image conditions (C-2 and C-3); the difference lies between them and the condition of direct inspection (C-1). The nil perceptions show a moderate but significant increase, for all viewing conditions, when the expectancy is changed from expecting all real faces (S-1) to expecting only about half to be real. For each Set, however, the striking feature is the marked increase in nil perceptions in proceeding from item groups composed of all real faces through those with half real and false to those entirely false under Condition 1 only. Looking at the picture for misperceptions (Figure 4) the situation is precisely reversed.

In short, in perceiving the real items, there was no difference between any of the three viewing conditions. But under Conditions 2 and 3 subjects were strikingly prone to misperceive false faces as real even when warned (S-2)---although less prone when warned.

In analyzing perceptions and misperceptions under Condition 2, in terms of the number of exposures called for, a reverse relationship was revealed, as shown in Figure 5. Most of the perceptions were consummated with a single tachistoscopic exposure; most of the misperceptions were consummated with a triple exposure.

As shown in Table XI-6 an appreciably longer time was taken in making an incorrect closure than in making a correct one.

TABLE XI-1

GRAECO-LATIN SQUARE DESIGN EMPLOYED IN EXPERIMENT NO. VIII

Order of Sets (S), Conditions (C), and Item Groups (I)

Subjects	First S-C-I	Second S-C-I	Third S-C-I	Fourth S-C-I	Fifth S-C-I	Sixth S-C-I
1	1-1-1	1-2-3	1-3-5	2-1-2	2-2-4	2-3-6
2	1-2-1	1-3-3	1-1-5	2-2-2	2-3-4	2-1-6
3	1-3-1	1-1-3	1-2-5	2-3-2	2-1-4	2-2-6
4	2-1-1	2-2-3	2-3-5	1-1-2	1-2-4	1-3-6
5	2-2-1	2-3-3	2-1-5	1-2-2	1-3-4	1-1-6
6	2-3-1	2-1-3	2-2-5	1-3-2	1-1-4	1-2-6
7	1-1-3	1-2-5	1-3-2	2-1-4	2-2-6	2-3-1
8	1-2-3	1-3-5	1-1-2	2-2-4	2-3-6	2-1-1
9	1-3-3	1-1-5	1-2-2	2-3-4	2-1-6	2-2-1
10	2-1-3	2-2-5	2-3-2	1-1-4	1-2-6	1-3-1
11	2-2-3	2-3-5	2-1-2	1-2-4	1-3-6	1-1-1
12	2-3-3	2-1-5	2-2-2	1-3-4	1-1-6	1-2-1
13	1-1-5	1-2-2	1-3-4	2-1-6	2-2-1	2-3-3
14	1-2-5	1-3-2	1-1-4	2-2-6	2-3-1	2-1-3
15	1-3-5	1-1-2	1-2-4	2-3-6	2-1-1	2-2-3
16	2-1-5	2-2-2	2-3-4	1-1-6	1-2-1	1-3-3
17	2-2-5	2-3-2	2-1-4	1-2-6	1-3-1	1-1-3
18	2-3-5	2-1-2	2-2-4	1-3-6	1-1-1	1-2-3
19	1-1-2	1-2-4	1-3-6	2-1-1	2-2-3	2-3-5
20	1-2-2	1-3-4	1-1-6	2-2-1	2-3-3	2-1-5
21	1-3-2	1-1-4	1-2-6	2-3-1	2-1-3	2-2-5
22	2-1-2	2-2-4	2-3-6	1-1-1	1-2-3	1-3-5
23	2-2-2	2-3-4	2-1-6	1-2-1	1-3-3	1-1-5
24	2-3-2	2-1-4	2-2-6	1-3-1	1-1-3	1-2-5
25	1-1-4	1-2-6	1-3-1	2-1-3	2-2-5	2-3-2
26	1-2-4	1-3-6	1-1-1	2-2-3	2-3-5	2-1-2
27	1-3-4	1-1-6	1-2-1	2-3-3	2-1-5	2-2-2
28	2-1-4	2-2-6	2-3-1	1-1-3	1-2-5	1-3-2
29	2-2-4	2-3-6	2-1-1	1-2-3	1-3-5	1-1-2
30	2-3-4	2-1-6	2-2-1	1-3-3	1-1-5	1-2-2
31	1-1-6	1-2-1	1-3-3	2-1-5	2-2-2	2-3-4
32	1-2-6	1-3-1	1-1-3	2-2-5	2-3-2	2-1-4
33	1-3-6	1-1-1	1-2-3	2-3-5	2-1-2	2-2-4
34	2-1-6	2-2-1	2-3-3	1-1-5	1-2-2	1-3-4
35	2-2-6	2-3-1	2-1-3	1-2-5	1-3-2	1-1-4
36	2-3-6	2-1-1	2-2-3	1-3-5	1-1-2	1-2-4

TABLE XI-2

GROUPING OF TEST-ITEMS ACCORDING TO ORDER OF PRESENTATION

Item Groups	Items*							
I-1	1	14	8	67	5	12	69	7
I-2	16	18	6	17	34	32	13	22
I-3	25	(11)	24	26	(37)	33	(46)	(70)
I-4	(2)	49	23	(36)	62	51	(15)	(9)
I-5	(29)	(64)	(35)	(52)	(19)	(58)	(45)	(4)
I-6	(44)	(48)	(21)	(20)	(63)	(60)	(59)	(30)

*Bracketed items were false items---achieved in some instances by presenting real items upside down.

TABLE XI-3

ANALYSIS OF VARIANCE FOR REAL ITEMS PERCEIVED

Source		df	SS	MS	F	p
Sets	(S)	1	4.89	4.89	---	
Conditions	(C)	2	9.68	4.84	---	
Item Groups	(I)	2	10.68	5.34	---	
Order	(O)	5	40.70	8.14	2.49	(.05 = 2.37)
S x C		2	5.80	2.90	---	
S x I		2	2.91	1.45	---	
S x O		5	28.95	5.79	---	
C x I		4	22.21	5.55	---	
C x O		10	55.44	5.54	---	
I x O		10	80.77	8.08	2.47	(.025 = 2.27)
Residual		64	238.30	3.72		
Total		107	500.33			

TABLE XI-4

ANALYSIS OF VARIANCE FOR NIL PERCEPTIONS

Source		df	SS	MS	F	p
Sets	(S)	1	60.16	60.16	16.95	(.01 = 6.63)
Conditions	(C)	2	154.19	77.09	21.72	(.01 = 4.61)
Item Groups	(I)	5	177.44	35.48	10.00	(.01 = 3.02)
Order	(O)	5	15.44	3.09	---	
S x C		2	4.09	2.04	---	
S x I		5	8.45	1.69	---	
S x O		5	7.95	1.59	---	
C x I		10	111.03	11.10	3.13	(.01 = 2.32)
C x O		10	34.70	3.47	---	
I x O		25	106.95	4.28	---	
Residual		145	515.44	3.55		
Total		215	1195.84			

TABLE XI-5

ANALYSIS OF VARIANCE FOR ALL ITEMS MISPERCEIVED

Source		df	SS	MS	F	p
Sets	(S)	1	38.34	38.34	8.67	(.01 = 6.81)
Conditions	(C)	2	112.29	56.14	12.70	(.01 = 4.75)
Item Groups	(I)	5	268.08	53.62	12.13	(.01 = 3.14)
Order	(O)	5	2.42	.48	---	
S x C		2	5.01	2.50	---	
S x I		5	12.75	2.55	---	
S x O		5	15.07	3.01	---	
C x I		10	105.49	10.55	2.39	(.01 = 2.44)
C x O		10	47.32	4.73	---	
I x O		25				
Residual		145	640.88	4.42		
Total		215	928.11			

TABLE XI-6

MEAN TIME IN SECONDS FOR PERCEPTIONS AND MISPERCEPTIONS

	Perceived	Misperceived	Called Duds
Condition 1	2.17	5.44	5.72
Condition 3	3.63	5.24	5.80
Total	2.92	5.29	5.76

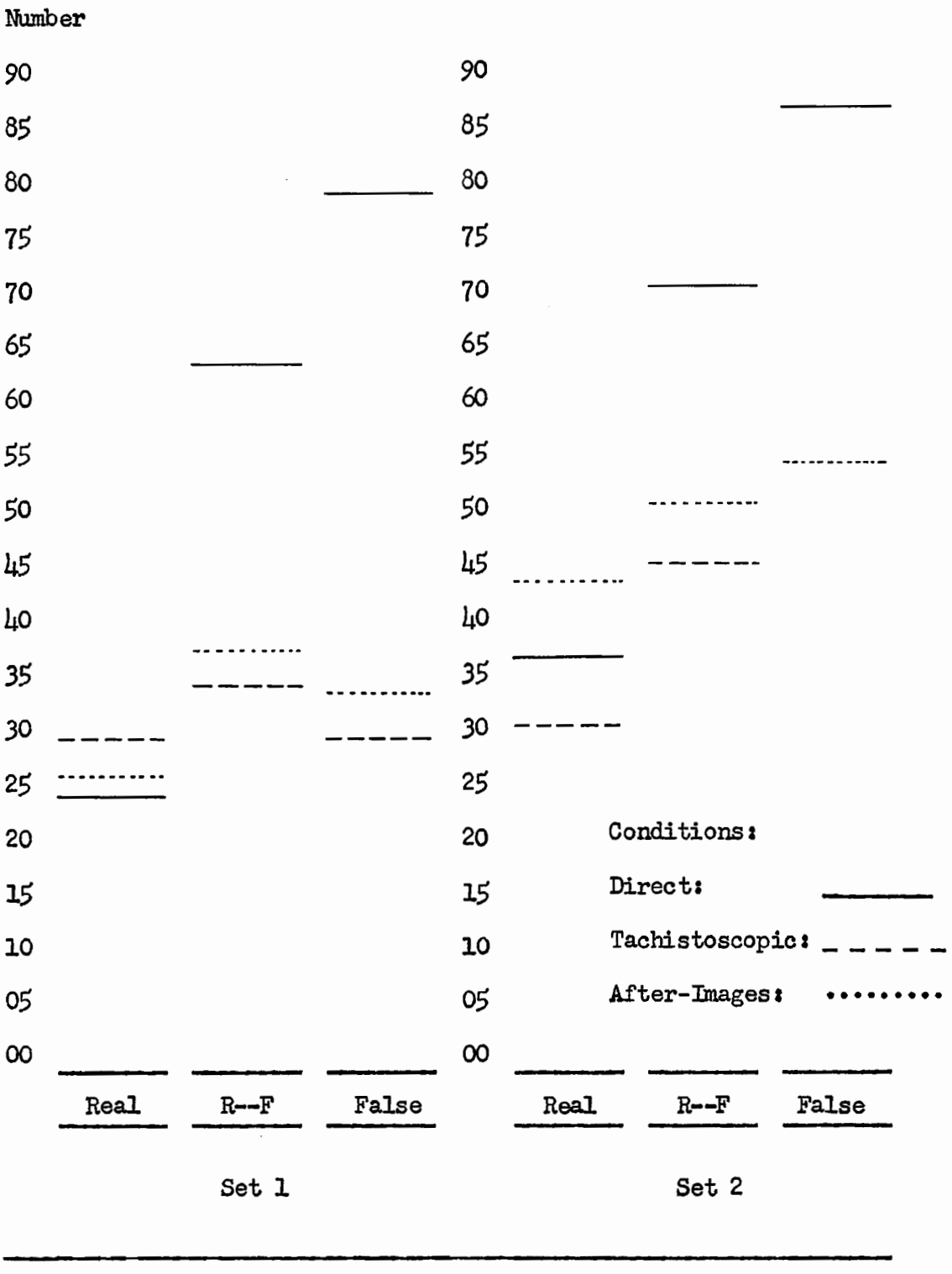


FIGURE 3. The effect on nil perceptions attributable to changed perceptual expectancy under different viewing conditions.

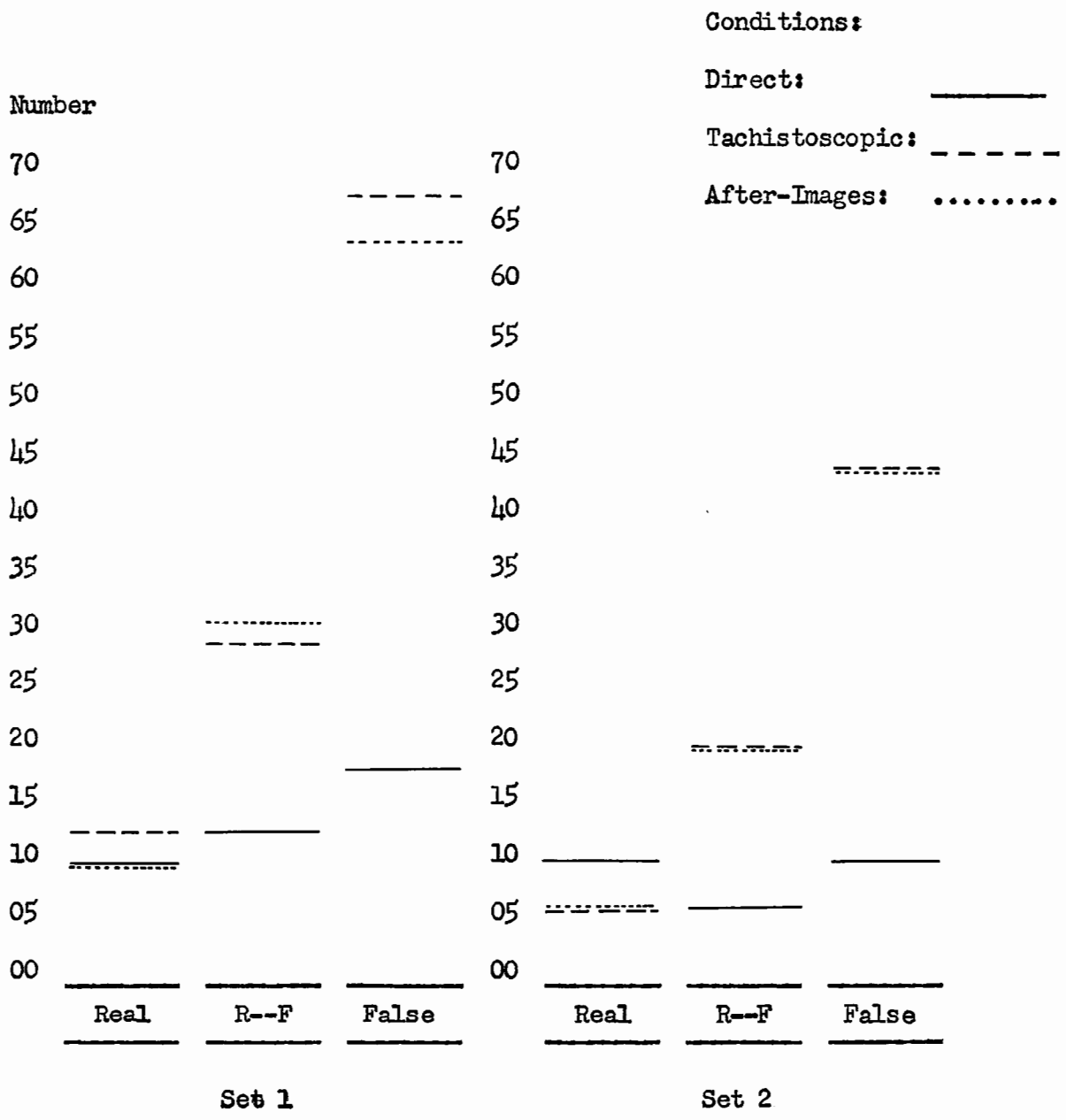


FIGURE 4. The effect on misperceptions attributable to changed perceptual expectancy under different viewing conditions.

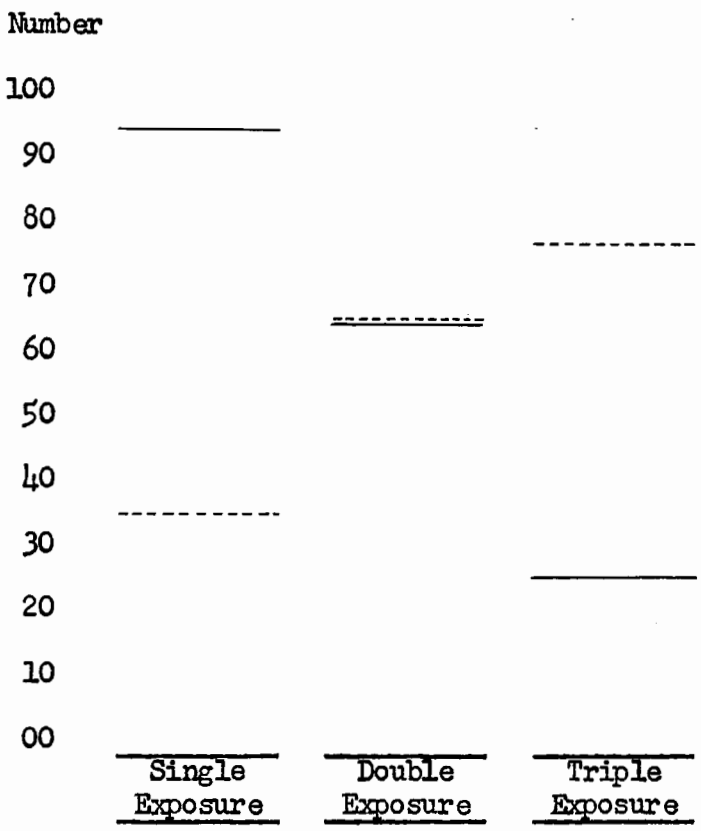


FIGURE 5. Breakdown of perceptions and misperceptions in terms of the number of tachistoscopic exposures required.

EXPERIMENT XII

CLOSURE WITH ITEM-NEGATIVES

Purpose. This was to see, first, if perception of the Closure Faces in their photographically negative state differed from perception of them in their positive state; and, second, to see if previous experience with the test-items in their positive state affected perception of them in their negative state.

Procedure. An analysis of variance design was employed based on a 2 x 3 x 6 x 10 Graeco-Latin Square, shown in Table XII-1. Two viewing conditions were: direct inspection (D) for 5 seconds; and a single tachistoscopic exposure (T) at 1/18 of a second. Three treatments were: original presentation of photographic negatives of the test-items (N); original presentation of the item-positives, with, later in the test series, presentation of these same items in their negative state (PN); original presentation of item-positives with, later in the test series, presentation of these same items in their negative state, reversed (from left to right) in respect of their original orientation as item-positives (PNR). The 42 items were randomly sorted into 6 groups of 7 items each, shown in Table XII-2. There was a ten-stage order of presentation. The design called for a minimum of 36 subjects.

Table XII-1 reveals the actual experimental procedure for any given subject. A subject dealt initially with two item-groups, given as positives, under one condition (say, direct inspection); he

dealt with a third item-group, given as negatives, under that same condition; in the fourth and fifth order, he was presented with, respectively, the negatives of one of the item-groups earlier dealt with as positives (the PN treatment) or the negatives reversed of the other of the item-groups earlier dealt with as positives (the PNR treatment)--both these treatments being given under the same condition (direct inspection) employed in the first, second, and third orders; the second half of the test session duplicated this procedure, using new item-groups in orders six, seven, and eight, and employing the other condition (in this instance, the tachistoscopic) throughout.

Subjects were given the usual explanation and practice concerning the test. They were unaware of the experimental procedure, of the different item-groups, and of the presence of the photographic negatives. The last 18 subjects were told that during the series they might see a few items which they had seen earlier and that they should report any such instances. All items so reported for both the first 18 and the last 18 subjects were noted.

Subjects were seated four feet from the screen, about 30 degrees off center. The screen image was 20 x 30 inches. The screen was a Radiant white, pebbled screen; the brightness of the projected test-item was about 1.6, measured with a Weston Master II Universal Exposure Meter.

Subjects were 36 undergraduates, 15 men and 21 women,

with a mean age of 20 years.

Details of the apparatus and the testing procedures are given in Chapter IV.

Findings. The analysis of variance is shown in Table XIII-3. The significant variation due to Item-Groups indicates that the random sorting of items did not result in groups of equal difficulty. There is an interaction, which is probably significant, but would not easily be analyzable, between Item-Groups and Treatments.

The findings of major significance have to do with, first, differences due to Treatments, as shown in Table XII-4, and with the number of items that subjects remarked having seen before, shown in Tables XII-5 and XII-6.

No subjects seemed to realize (when indirectly questioned after the testing session) and none reported the presence of photographic negatives in the series, although each, in fact, was presented with 42 items in that state. Only 100 instances were reported of an item having been seen before, when the negatives of positives seen earlier were presented, although each subject, in fact, was given 24 such presentations.

It is a most interesting finding, therefore, that the perceptual performance with negatives, of which the positives had earlier been seen, was strikingly better (in fact as good as with the positives) than the performance with negatives where there had been no prior experience with the positives.

TABLE XII-1 - GRAECO-LATIN SQUARE DESIGN FOR EXPERIMENT XII

S	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
1	I-1 P D	I-2 P D	I-3 N D	I-1 NR D	I-2 N D	I-4 P T	I-5 P T	I-6 N T	I-4 N T	I-5 NR T
2	P D	N D	P D	I-1 N D	I-3 NR D	P T	N T	P T	I-4 NR T	I-6 N T
3	N D	P D	P D	I-2 NR D	I-3 N D	N T	P T	P T	I-5 N T	I-6 NR T
4	P T	P T	N T	I-1 NR T	I-2 N T	P D	P D	N D	I-4 N D	I-5 NR D
5	P T	N T	P T	I-1 N T	I-3 NR T	P D	N D	P D	I-4 NR D	I-6 N D
6	N T	P T	P T	I-2 NR T	I-3 N T	N D	P D	P D	I-5 N D	I-6 NR D
7	I-2 P D	I-3 P D	I-4 N D	I-2 N D	I-3 NR D	I-5 P T	I-6 P T	I-1 N T	I-5 NR T	I-6 N T
8	P D	N D	P D	I-2 NR D	I-4 N D	P T	N T	P T	I-5 N T	I-1 NR T
9	N D	P D	P D	I-3 N D	I-4 NR D	N T	P T	P T	I-6 NR T	I-1 N T
10	P T	P T	N T	I-2 N T	I-3 NR T	P D	P D	N D	I-5 NR D	I-6 N D
11	P T	N T	P T	I-2 NR T	I-4 N T	P D	N D	P D	I-5 N D	I-1 NR D
12	N T	P T	P T	I-3 N T	I-4 NR T	N D	P D	P D	I-6 NR D	I-1 N D
13	I-3 P D	I-4 P D	I-5 N D	I-3 NR D	I-4 N D	I-6 P T	I-1 P T	I-2 N T	I-6 N T	I-1 NR T
14	P D	N D	P D	I-3 N D	I-5 NR D	P T	N T	P T	I-6 NR T	I-2 N T
15	N D	P D	P D	I-4 NR D	I-5 N D	N T	P T	P T	I-1 N T	I-2 NR T
16	P T	P T	N T	I-3 NR T	I-4 N T	P D	P D	N D	I-6 N D	I-1 NR D
17	P T	N T	P T	I-3 N T	I-5 NR T	P D	N D	P D	I-6 NR D	I-2 N D
18	N T	P T	P T	I-4 NR T	I-5 N T	N D	P D	P D	I-1 N D	I-2 NR D
19	I-4 P D	I-5 P D	I-6 N D	I-4 N D	I-5 NR D	I-1 P T	I-2 P T	I-3 N T	I-1 NR T	I-2 N T
20	P D	N D	P D	I-4 NR D	I-6 N D	P T	N T	P T	I-1 N T	I-3 NR T
21	N D	P D	P D	I-5 N D	I-6 NR D	N T	P T	P T	I-2 NR T	I-3 N T
22	P T	P T	N T	I-4 N T	I-5 NR T	P D	P D	N D	I-1 NR D	I-2 N D
23	P T	N T	P T	I-4 NR T	I-6 N T	P D	N D	P D	I-1 N D	I-3 NR D
24	N T	P T	P T	I-5 N T	I-6 NR T	N D	P D	P D	I-2 NR D	I-3 N D
25	I-5 P D	I-6 P D	I-1 N D	I-5 NR D	I-6 N D	I-2 P T	I-3 P T	I-4 N T	I-2 N T	I-3 NR T
26	P D	N D	P D	I-5 N D	I-1 NR D	P T	N T	P T	I-2 NR T	I-4 N T
27	N D	P D	P D	I-6 NR D	I-1 N D	P T	P T	P T	I-3 N T	I-4 NR T
28	P T	P T	N T	I-5 NR T	I-6 N T	P D	P D	N D	I-2 N D	I-3 NR D
29	P T	N T	P T	I-5 N T	I-1 NR T	P D	N D	P D	I-2 NR D	I-4 N D
30	N T	P T	P T	I-6 NR T	I-1 N T	N D	P D	P D	I-3 N D	I-4 NR D
31	I-6 P D	I-1 P D	I-2 N D	I-6 N D	I-1 NR D	I-3 P T	I-4 P T	I-5 N T	I-3 NR T	I-4 N T
32	P D	N D	P D	I-6 NR D	I-2 N D	P T	N T	P T	I-3 N T	I-5 NR T
33	N D	P D	P D	I-1 N D	I-2 NR D	N T	P T	P T	I-4 NR T	I-5 N T
34	P T	P T	N T	I-6 N T	I-1 NR T	P D	P D	N D	I-3 NR D	I-4 N D
35	P T	N T	P T	I-6 NR T	I-2 N T	P D	N D	P D	I-3 N D	I-5 NR D
36	N T	P T	P T	I-1 N T	I-2 NR T	N D	P D	P D	I-4 NR D	I-5 N D

TABLE XII-2

GROUPING OF TEST-ITEMS BY ORDER OF PRESENTATION

Item Groups	Items						
I-1	33	14	24	67	5	2	12
I-2	1	56	65	62	7	69	49
I-3	25	8	40	11	70	53	37
I-4	16	39	6	47	32	13	9
I-5	42	18	17	36	10	34	66
I-6	51	22	23	38	15	35	26

TABLE XII-3

ANALYSIS OF VARIANCE FOR PERCEPTION OF ITEM-NEGATIVES

Source	df	SS	MS	F	p
Conditions (C)	1	2.84	2.84	---	
Treatments (T)*	2	95.54	47.77	16.71	(.001= 6.91)
Item Groups (I)	5	139.16	27.83	9.73	(.001= 4.62)
Order (O)	9	29.38	3.26	---	
C x T	2	.29	.15	---	
C x I	5	40.56	8.11	2.83	(.05= 2.26)
C x O	9	17.27	1.92	---	
T x I	10	69.92	6.99	2.44	(.01= 2.41)
T x O	18	60.59	3.37	---	
I x O	45	161.45	3.59	---	
C x T x I	10	59.75	5.98	2.09	(.05= 1.87)
C x T x O	18	28.58	1.59	---	
Residual	225	643.16	2.86		
Total	359	1348.49			
* Breakdown:					
N vs $\frac{PN + PNR}{2}$	1	88.50	88.50	30.94	(.001=10.83)
PN vs PNR	1	7.04	7.04	2.46	

TABLE XII-4

SCORES BY TREATMENT AND ITEM GROUPS

Item Groups	Treatments N	PN		PNR		Total
	N	P	N	P	NR	
I-1	20	28	30	40	38	156
I-2	23	45	42	22	23	155
I-3	41	48	54	62	50	255
I-4	25	44	40	41	27	177
I-5	29	37	44	48	40	198
I-6	25	57	58	50	41	231
Total	163	259	268	263	219	1172
Percent Accomplished	30	51	53	52	43	

TABLE XII-5

INSTANCES OF ITEMS REPORTED AS SEEN EARLIER

Conditions	First 18 Subjects*	Last 18 Subjects	Total
PN Treatments, Direct Inspection	23	47	70
PN Treatments, Tachistoscopic	3	27	30
Total	26	74	100

* Note: The first 18 subjects were not informed, the last 18 subjects were, that they might see items later in the series that they had seen earlier; all reports of this were noted.

TABLE XII-6

INSTANCES OF ITEMS REPORTED AS SEEN EARLIER

Treatments	First 18 Subjects	Last 18 Subjects	Total
PN Treatment	15	46	61
PNR Treatment	11	28	39
Total	26	74	100

CHAPTER VI

GENERAL OBSERVATIONS AND CONCLUSIONS

The aim, in the foregoing series of experiments, was to ascertain whether perception of the Closure Faces would be facilitated or inhibited by (i) variations in the stimulus-qualities of the test-items; (ii) complication of the viewing conditions, notably with respect to restraint of eye-movements; and, (iii) subjective factors, such as experience with an inconsistent item-series, and state of perceptual expectancy. It was presumed that (i) and (ii) would not significantly affect closure performance; and it was suggested that experimental negation of the necessity or efficacy of eye-movements would have implications for perceptual theory.

These are the specific propositions that have been found experimentally acceptable or non-acceptable.

Stimulus Qualities

1. The brightness and clear definition of the black and white elements of the test-items are not factors in their perception.

   This was confirmed in Experiments VI and VII by comparing performance with items markedly dulled and blurred with items clearly and brightly defined. Counter evidence might be the finding in Experiment X that performance with the negative after-images in their poorest state (induced

under steady light) was significantly less efficient than when they were clearly defined (induced under flickering light). The proviso should be added to the foregoing hypothesis, therefore: under the condition of free, direct inspection.

2. The photographic negatives of the test-items are incomprehensible.

This was not found so. In Experiment XII where subjects were instructed to see all items (unaware of the presence of negatives among positives) 30 percent of negatives were seen, as against 50 percent of the positives---both in single-shot tachistoscopic representation and direct (5 seconds long) inspection. However, use of the negatives in "burning-in" the images for their subsequent induction as negative after-images (as perceptible positives) did not confer any perceptual advantage, as demonstrated in Experiment II.

3. Closure is facilitated by the congruity of the graphic "parts" with the natural structure of the implied whole object being represented.

This was not specifically proved; it is, however, implied by the findings in Experiments IV and V, and Experiments VI and VII. In the former pair, perception of incomplete faces may be compared with perception of incomplete words. With both types of items, the graphic "parts" were congruent with their positions in the completed whole items. The level and facility

of successful accomplishment were approximately identical for both types of items. In the latter pair, the "parts" of the letters were not congruent with the whole letters, but were such as to conceal and distort the underlying letter-forms. The over-all accomplishment with the letters was 46 percent compared to 64 percent for the faces; and the mean time per letter was 9.3 seconds compared to 4.0 seconds per face.

Viewing Conditions

4. Eye-movements are neither necessary for nor essentially contributory to perception of the Closure Faces.

This is clear from the following findings. In Experiment III the accomplishment with triple tachistoscopic presentations was significantly superior to---and the accomplishment with negative after-images was equal to---that where items were available for direct inspection for 30 seconds. Again, over-all performance in Experiment IV (using triple tachistoscopic exposures) was 70 percent; in Experiment VI, where the method was that of direct inspection for 30 seconds, it was 64 percent. That the single-double-triple exposure convention used in these was not a critical factor is evident from Experiment XII where only one (single) tachistoscopic exposure was used (at 1/18 second) and the method of direct inspection (for 5 seconds); here, the accomplishment in both instances was 50 percent.

5. Time, except as an instant, is neither necessary for nor essentially contributory to perception of the Closure Faces. This is a corollary of the evidence just cited. Some additional facts are to be noted. Of the closures effected tachistoscopically in Experiment III, 48 percent were accomplished on the single exposure, 39 percent on the double, and 13 percent on the triple. In Experiment IX where subjects, under the tachistoscopic condition, were required to effect closures on one (single) or a second (single) exposure, the over-all performance was 68 percent, equally divided between the two. Looking at the time required, in direct inspection, in Experiment VI, for example: the average time taken to close was four seconds; 64 percent of closures were effected in the first two seconds following presentation of the test-item, or 80 percent within the first five seconds.

6. Under favorable viewing conditions the test-items are seen as readily when presented peripherally as centrally. This is the finding in Experiment VIII, using tachistoscopic presentation, where the perceptual accomplishment was 71 percent.

7. The presence of intermittent light, flickering at three cycles per second, has not, per se, any effect on closure performance; (neither has the addition of synchronous sound); but its presence markedly facilitates closure with negative after-images.

Experiment I located the optimal flicker-rate for enhancing the duration and clarity of the negative after-images at about

three cycles per second. Experiment II showed that it was not, in itself, an inhibiting or facilitating factor in effecting the closures. Experiment X revealed that 75 percent of the items were seen under the condition of intermittent light and only 50 percent under the normal condition of steady light; the addition of sound flickering simultaneously with the light had no additional effect of any kind.

Subjective Factors

8. Inconsistencies or anomalies in the test-item series have no effect on perceptual performance.

This has to be qualified. In Experiment III where there was a 1:2 admixture of false faces to real (the subject being told all were real) 73 percent of the real were seen---consistent with the average accomplishment in other experiments---and 38 percent of the false were erroneously "seen". In Experiment XI where they were misinformed concerning the true-false composition of the item-groups and were, additionally, in one half of the test session "set" to see all real faces, and in the other half "set" to see half of them as false, the accomplishment on the real was a-typically low (58 percent)---but not as a consequence of "set"; similarly, misperceptions of the false were few (18 percent) ---in part attributable to "set". In Experiment XII, where, instead of false faces, runs of photographic negatives

of the real faces were interspersed (unknown to the subjects) among runs of the positives, accomplishment on the positives went down to 50 percent, and the misperceptions were 18 percent. Thus, the presence of anomalous features in the perceptual context, even when unknown to the subjects (for example, in the experiments quoted, no subject suggested that there were false faces or photographic negatives in the series), markedly inhibits what may be called the perceptual "investment".

9. The state of perceptual expectancy or "set" has no effect on perception of the Closure Faces.

This has to be qualified. There are corollaries, here, to the evidence just cited, above. Again, referring to Experiment XI: it was demonstrated that the two different "sets" had no effect on correct perceptions of the real Closure Faces, and this was true under the three viewing conditions (direct inspection, tachistoscopic, and negative after-images); however, the different "sets" had marked effects on the numbers of nil perceptions and misperceptions (vide Figures 3 and 4); these were minimal, for all viewing conditions, where the series was composed of real faces; they remained minimal, regardless of "set", for the method of direct inspection only, when (i) the item series was half composed of false items and (ii) when it was wholly so composed; but they went up markedly,

proportionately, and identically, under (i) and (ii), for the methods of tachistoscopic and negative after-image presentation under both sets---but significantly less so under Set 2 where they were warned of the presence of false items. Therefore, this proviso must be added to the above statement: but it markedly affects misperceptions in circumstances where subjects have but one view of the test-items.

10. Perception of the Closure Faces is, in some unknown way, dependent on the unapprehended implications of past experience with similar sense-objects.

This seems to be the import of Experiment XII, where a puzzling phenomenon is revealed. Here, under well-controlled conditions, subjects were invited to see the photographic negatives of the test-items (believing them to be positives of normally perceptible depictions); they succeeded in 30 percent of instances; they were also given groups of positives to see; their success was 50 percent; later in the experimental session they were given (a fact unknown to them) the negatives of those positives--in, respectively, their original, and reversed, orientation---to see, and their accomplishment was 50 percent. The finding is highly significant in view of the facts (i) that those subjects warned to look out for and report the reappearance

of items seen earlier in the series reported only 17 percent of such instances, (ii) those subjects not so warned reported only 6 percent of such instances, (iii) none seemed to surmise the existence of the negatives at any time any where in the total series, and, (iv) reversing the orientation had no effect. This was equally so under the two viewing conditions used, direct representation and tachistoscopic. Evidently, a latent or predisposing kind of learning or activation occurred, as a consequence of exposure to the early positives, which automatically facilitated perception of their negatives, when these were presented later.

The foregoing findings are grounded only on the experimental facts. The following general observations arise from the author's experience watching and listening to the subjects, during the experiments, and discussing their experience with them after the testing sessions.

Perceiving the Closure Faces was a "closure" experience, marked by the initial straining to see, and the "aha! " conclusion. This was most notable, and evidently most pleasurable for the subjects, with induction of the negative after-images.

There seemed little doubt that subjects were not seeing rough approximations of human faces, but very particular, characteristic kinds. The precise, qualitative descriptions offered by many subjects were surprising, and it is now to be regretted that a random sampling of answers was not tape-recorded to demonstrate this. But, as an example, item 15 , one of three atypical items (15,26,28) inserted in the

series, was seen and described as a Negro by 5 of the 16 subjects in Experiment VI. Those subjects who were most facile at effecting closure gave the richest and most detailed descriptions of the faces.

Attempts to fabricate faces or answers were negligible. Subjects, almost without exception, said that most of their closures were effected at a glance; and that when they looked for the face it would suddenly and surprisingly "be there", if it came at all.

The following general conclusions about the instance of closure seem to be warranted by all the evidence.

This kind of closure (perception of incompletely depicted human heads and faces) occurs automatically---that is, without the intervention of conscious, reasoning processes---and at a single glance. It is not essentially dependent on an ordinal integration of visual cues nor on successive visual fixations or scanning eye-movements.

The stimulus-object functions as a whole, and as a single stimulus. Its property of being a perceptual determinant derives from something other than the number, contrast, clarity, and graphic coherence of its parts; it derives from its implicative, over-all likeness to a familiar kind of human face; that is to say, the assembly of parts---however fragmentary and chaotic in their given lineal state and relationship---<u>happens to be</u> congruent with just such parts in just such places in the physiognomic context of a particular, completely revealed human face. It thus invokes, centrally, its <u>completed</u> counterpart.

This type of closure, effected at a glance, would seem to be very like normal perception. The latter, it has been suggested, (Chapter III), is a matter of fleeting glances, incidental to orientation within and procedure through a meaningful context of experience; it entails the briefest perceptual commerce with the visual field necessary to confirm the presence of, or to recognize the nature of, the familiar everyday objects of ordinary experience. A quick glance at a well-known face, for example, would result in instantaneous recognition. In this glance but a few of the over-all lineaments characteristic of the particular face would be noted, or need be noted, since, being compatible with the neural trace, engram, phase sequence, however called, which was the "memory" of that face, they would be sufficient to activate it so that the cognitive experience would be that of complete seeing, by virtue of the recognition. In a quick glance directed at an expected but unfamiliar face, again, similarly, but a few of the over-all lineaments would need to be grasped in that glance to permit its idiomatic recognition by virtue of its congruity with the "memories" of many such faces discriminated in past experience. In the present experimental instances, presentations were made where this latter situation was more or less duplicated; subjects were permitted---and it has been demonstrated that they needed---only a single glance at expected human heads and faces of particular, characteristic kinds, and, moreover, the visual information they were permitted to have was no more than the delineated high-lights that might be grasped in a rapid glance. The experimental situation was, then, in a sense, simulative of

or was a kind of anatomized version of, ordinary perception.

Such implication as this may have for perceptual theory would relate to the basic difficulty, "the crucial problem of perception," pointed out by Hebb (17 pp. 17-18).

> One must decide whether perception is to depend (1) on the excitation of specific cells or (2) on a pattern of excitation whose locus is unimportant. Current opinion seems tacitly to have accepted the Gestalt argument (and Lashley's argument) that the only tenable assumption is the second of these possibilities.
>
> The theory to be presented here is diametrically opposed to this aspect of Gestalt theory, and is based on assumption 1, that a particular perception depends on the excitation of particular cells at some point in the central nervous system. Now the Gestalt argument depends, I believe, on another assumption: that when one perceives a simple figure (such as square or circle) one perceives it directly as a distinctive whole, without need of any learning process and not through a prior recognition of the several parts of the figure. If one makes this assumption---if the perception of a square is as simple and immediate as it seems to us as adults---I believe that the Gestalt argument is unanswerable. But if on the other hand the perception is additive, a serial reconstruction (though very rapid and "unconscious" for the normal adult), the theoretical problem would be very much changed..... accordingly, an attempt is made to show that quite simple diagrams are not perceived directly as distinctive wholes---that, though the stimulus has a unitary action in the figure-ground relationship, the perception of identity depends on a series of excitations from the parts of the stimulating diagram.

While the present findings do not rule out Hebb's line of reasoning they would seem to call it into question. Hebb grants that a familiar simple figure does seem to be instantly perceived as a whole; but he suggests this may be

illusory and maintains that the figure will in any event be more clearly perceived with a succession of visual fixations; and this, he thinks, is certainly the way one learns to perceive it. He might argue that even with a single fixation lasting for but a fraction of a second the visible parts could have a serial action adding up to an apparently instantaneous perception of a whole. The sensory effect might outlast the actual exposure and the different segments of the afferent process might be "held" for the fractional time necessary for their serial action. These possibilities would exist for the incomplete faces used in this study for, although they are much more complex presentations than simple figures like triangles or squares, they are, nevertheless, highly familiar objects.

But the present findings do seem to lend strength to the idea that perception depends "on a pattern of excitation whose locus is unimportant". The perceptual performance is rather remarkable in that, under highly restricted viewing conditions these very incomplete representations of particular kinds of human heads and faces were readily recognized and distinguished with a brief glance or a single fixation. The perceptual task was of such a kind and difficult enough that if any process of serial incorporation by successive visual fixations could clarify these kinds of percepts it would have been expected to operate and reveal the superiority of the method of direct inspection; but there is no such evidence. If

perceptual learning is founded on successive visual fixations and ordinal patterns of excitations it would seem reasonable to suppose that when, under the restrictions of the present experiments, perceptual arrests occurred, resort to scanning eye-movements would be a natural regression likely to be reconstitutive of elements which had been earlier constitutive of the percept; but evidence of this is lacking.

The findings suggest that it may be reasonable to suppose that initial and subsequent sensory acquaintance with commonplace objects depends on single, panoramic glances aimed in their general direction. Repeated visual acquaintance with a great many varied instances of a commonplace object, seen glance-wise, directly and peripherally and from many angles under diverse conditions of lighting and in various settings, could, presumably, result in a wide-spread neural store of these panoramic "wholes". Thus, perceptual performance would depend on a configural pattern of simultaneous excitations whereby an incompletely represented but implied whole "comes on" at once as a completed perception. While this may be implied by the results of the present investigation, proof at the level required---namely, in the integrative central neural processes---is lacking. But, on the other hand, if the perceptual situation in these present experiments may be considered to be favorable to the kind of perceptual processes postulated by Hebb or Gibson, then it has to be noted that they did not appear to operate.

On the question of individual differences in facility in perceptual closure, the present series of studies are not, nor were they designed to be, directly informative. The following points come out, however.

1. Individuals differ markedly from one another, and any one individual's performance is quite consistent, in terms of over-all accomplishment on successive item-groups and the speed with which particular closures are effected. In view of the type of item employed in the present studies, it might be a tenable assumption that individual differences in prior experience with, or familiarity with the objects depicted, is not a critical differentiating factor. What such factors might be is still a matter of speculation.
2. There is, perhaps, some evidence of an unknown population difference. It may be noted that in Experiment II (where subjects were young offenders in a reformatory), performance with the negative after-images was significantly poorer than under the other viewing conditions. This was not so with the other test populations used.
3. There is a significant correlation between closure accomplishment and speed in effecting closures. For the 16 subjects in Experiment VI this Rank-Order

Correlation was .67; and for the 36 subjects in Experiment XI, it was .50. It may be noted, also, that item-difficulty is not significantly correlated with speed of closure. In Experiment VI, for example, the mean time for effecting closure on the 16 more difficult items (judged by numbers seen) was 4.50 seconds compared to 3.75 seconds for the 16 easier items.

Suggestions for future work in this field arise from unresolved points in the present study, of which only the more interesting can be offered.

1. How important are the high-lights and shadows (the blacks and whites) in facilitating perception of these incomplete, physiognomic presentations? The findings in Experiment XII suggest they may be less important than one would suppose. With much faster tachistoscopic speeds would there come a point where negatives and positives would be seen equally well? Is there a possibility that the latent, predetermining property of these Closure Faces resides in their implicit face-form, in their two-dimensional aspect, with the three-dimensional aspect negligible?
2. Does framing the pictures have any effect? Would the present results be achieved if the faces were

presented only as high-lighted (white) features on a completely black, unframed, and unbound background?

3. Informal trials with unframed faces slowly rotated (on the screen) from abnormal horizontal positions into their natural vertical positions had this result: subjects watched, without comprehension, and evidently unable to close, until, at some critical angle approaching the vertical the face suddenly appeared. This phenomenon could be exactly measured; and there might be useful implications concerning the nature and responsiveness of the---presumably---invoked memory traces whereby the completed percept is made possible.

4. Would the closure accomplishment on the negative after-images (employing the facilitatory inductive technique here developed) be significantly better employing subjects who had been amply practised in, and inured to, the technique, in advance, than employing naive and unpractised subjects, as in the present study?

5. Seven of the 27 subjects in Experiment X spontaneously volunteered the opinion that the addition of flickering sound, synchronous with the light, made it easier to keep their eyes on the fixation point, and "to concentrate" on seeing the after-image. More refined

experiments than that used in the present study would be required to reveal whether flickering sound affected the clarity or behavior of after-images.

6. The present study throws no light on the role of intermittent light in enhancing the negative after-images, nor on the many parameters that must be involved. This is clearly a specialized field of study, but perhaps one meriting attention. The early work by Miles (30) in this area appears to be unique.

7. A most interesting and puzzling phenomenon was revealed in Experiment XII, but not further studied. This was the latent effect of earlier experience with positive items on their later perception when given in their photographically negative state.

CHAPTER VII

SUMMARY

The intention was to learn more about factors affecting facility in perceptual closure, with the hope that this might throw more light on what transpires in the instance of closure and on the reasons for differences in closure facility between individuals.

A type of closure item was chosen which might be presumed to be universally familiar and interesting---namely, incomplete representations of the human head and face, based on photographs of real people. Fifty such representations were prepared for use in a slide projector.

Three basic viewing conditions were chosen so that the fundamental question of the necessity or essential usefulness of eye-movements (or successive visual fixations) could be examined. These conditions---which entailed the use of specially contrived projecting apparatus and techniques---were, (1) presentation of the test-item for direct visual inspection with ample time permitted for closure, (2) tachistoscopic presentation at speeds permitting only one visual fixation, and (3) induction of the positive test-items in the state of negative after-images, under the facilitating circumstance of flickering light to afford greater clarity and provide ample time for closure with but one visual fixation.

Twelve experiments were performed to reveal whether this kind of perceptual closure was significantly affected by: (1) graphic or

visual qualities of the stimulus-objects (for example, their brightness and clearness, their usefulness in their photographically negative state, and the contextual congruity of their parts); (2) viewing conditions (for example, direct inspection, tachistoscopic representation, induction of negative after-images---where time was maximal and minimal); (3) subjective factors (such as the introduction of inconsistent or anomalous features into the test-item series, and changed perceptual expectancy or "set").

The principal findings were that factors of the kind (1), above, had no effect. Factors of the kind (2) had no effect, except that misperceptions were significantly more common when subjects were permitted but one fixation; the notable finding, here, was that eye-movements (or successive visual fixations) conferred no perceptual advantage. Factors of the kind (3) were significantly inhibitory of closure.

It was concluded that closure is a fortuitous, instantaneous occurrence, accomplished at a single glance; that it is a central <u>whole</u> completion, predetermined by the configural pattern of the stimulus---that is, by its over-all congruence with neural "memories" of faces of that particular kind. It was suggested, therefore, that room for this kind of perceptual phenomenon must be found in contemporary theories of perceptual organization and performance. Finally, several unresolved questions were proposed for further study.

APPENDIX A

THE PROJECTING APPARATUS

A Leitz Prado 500 (watt) slide projector was placed behind an episcotister. This was a hollow cylinder of black metal, supported horizontally on axles fixed at each end. The cylinder surface was cut away on two sides permitting the beam from the projector to flash through it with each half turn. To one axle there was affixed a metal disc larger in diameter than the cylinder. Two curved slots were cut into its outer rim matching the cut away portions of the cylinder. The disc rotated between two photo-electric cells fixed to the base-plate of the apparatus, the slits permitting interruption of the photo-electric beam. This latter apparatus operated a photo-electric cell switch which in turn governed the sound out-put of an oscillator with headphones. To the same axle there was affixed a drive-wheel, hooked by a rubber driving belt to a variable speed (one-fifteenth horse-power) Bodine electric motor, governed by a Variac speed control unit. The same axle drove a Weston Tachometer and Meter (measuring revolutions per minute). The other axle of the cylinder was connected by right-angle gears (ratio 1:3) to a separate shaft at the front end of which was a large black cardboard disc, the outer third of which rotated in front of the projector lens. In this masking disc a hole was cut to permit passage of the projector beam. This cardboard disc was so synchronized with the cylinder that only one out of six flashes through the cylinder would be delivered to the screen. This could be quickly connected and disconnected.

With this apparatus it was possible, therefore, to produce flickering light, or flickering sound, or both synchronously, at a light-dark ratio of 50:50 at any desired rate up to 70 cycles per second. The set-up was versatile; the tachistoscopic feature could be quickly hooked in and pictures projected at any desired exposure rate; by inserting an opaque paper with a pin hole in it in one of the slide compartments (the picture being in the other) a dot of light as a fixation point could be put on the screen; the feature of cutting out five out of any six flickers (or, by this, of keeping a dot of light flashing as a fixation point on the screen) gave the experimenter time to shoot the slide holder across to afford one flash of the picture, and then flick it back, with a finger-tip---the whole procedure being quite practical and exact, for speeds up to thirty cycles per second.

In those experiments where time-readings were taken, the subject operated a toggle switch that turned on and off a small light on the experimenter's table. Readings were taken directly with a stop-watch---the nature of the experiments being such that precise and automatic time recordings were not essential, nor would they have been necessarily more reliable, since there were response variables over and above the mechanics of recording (for example, subjects almost invariably gave a verbal response coincident with the motor response---but sometimes forgot the latter).

APPENDIX B

THE CLOSURE FACES

TOP

46

CLOSURE FACES TEST

C.M. MOONEY

TOP

47

TOP

35

TOP

69

TOP

68

TOP

23

TOP

24

TOP

36

TOP

26

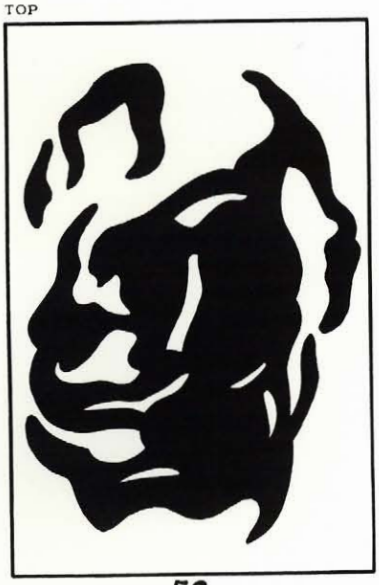
TOP

58

TOP

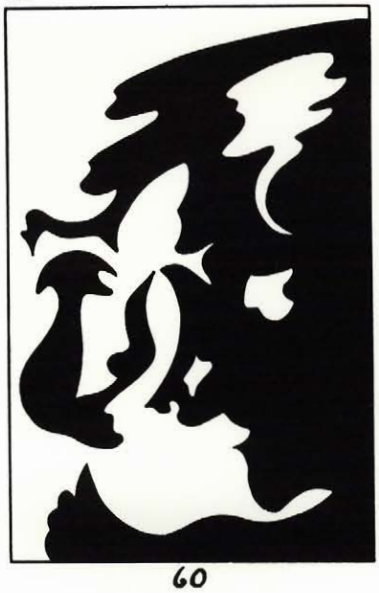
52

TOP



59

TOP



60

TOP

11

TOP

12

TOP

51

TOP

0

14

38

53

13

15

54

39

16

62

TOP

57

TOP

48

TOP

70

TOP

61

TOP

25

TOP

37

TOP

50

TOP

27

TOP

49

28

55

4

63

43

20

29

41

19

TOP

1

TOP

34

TOP

67

TOP

31

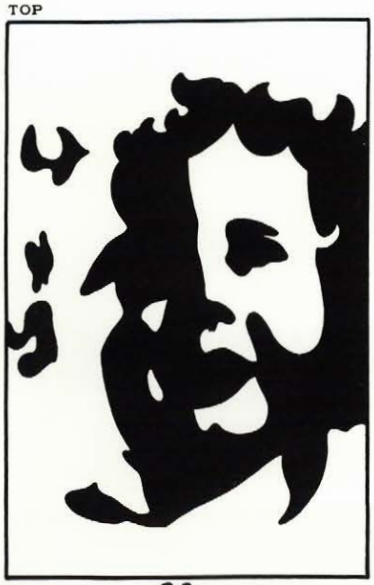
TOP

66

TOP

56

TOP



32

TOP

10

TOP

33

TOP

42

TOP

7

TOP

40

TOP

2

TOP

6

TOP

18

TOP

8

TOP

5

TOP

17

TOP

44

TOP

64

TOP

3

TOP

45

TOP

22

TOP

21

TOP

65

TOP

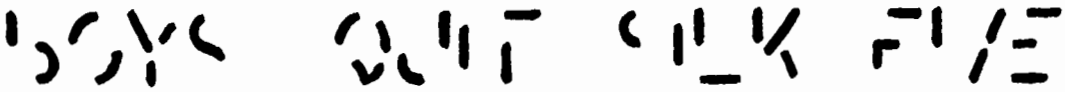
30

TOP

9

APPENDIX C

INCOMPLETE WORDS AND LETTERS



BOYS QUIT SILK FIVE

Examples of the 36 incomplete words used in Experiment V.

T B S N H

Examples of the 20 incomplete letters used in Experiment VII.

APPENDIX D

PROJECTED VISUAL IMAGES BY INTERMITTENT RETINAL STIMULATION

Miles (30) unique study of the formation of projected visual images by intermittent retinal stimulation, done forty years ago, is interesting not only for the findings, and the tentative theory of nerve-action derived therefrom, but for the ingenious techniques employed, and the possibility that such might be profitably employed again in studying visual and perceptual phenomena.

His work is introduced with these general observations.

> It is a well-known fact that when the eyes are closed after a bright light has been fixated, an after-image of the object can be seen. A similar image can also be seen if the eyes are directed to a uniformly illuminated background, immediately after the fixation. These images gradually fade; but if light is allowed to fall intermittently at a suitable rate on the closed eyelids, or if the intensity of the illumination of the screen on which the image is projected be varied at a regular rate, the following changes are observed. In each case, the fading and indistinct image is rapidly revived; it becomes clearer in outline; its intensity and objective character are strikingly increased; its duration is prolonged; and in many ways the image thus aroused forms such a marked contrast to the ordinary image that further investigation of its peculiarities is demanded. (p. 420)

> Even in the simplest experiments it was evident that, at a certain rate of stimulation, the image became much clearer than at any other rate. (p. 421)

Accordingly, Miles undertook:

"to determine the best rate of intermittent

> stimulation and the ratio of stimulus to rest most effective for the production of clear images. (p. 421)

His apparatus was a light-proof box fitted to the forehead, covering the eyes, with windows in front of the eyes. Upper and lower shutters on the windows came together, thus opening and closing the windows, like blinkers. By the use of electric current and magnets fitted on the apparatus, the open-shut periods (light-dark ratio) could be varied; also, the rate of blinking could be varied; and these features could be varied for each individual eye. Thus, frequency of stimulus, duration of stimulus, and coincidence of stimulus for the respective eyes, could all be systematically controlled.

He used mainly positive after-images, induced by fixating a brilliantly lighted filament. Of many interesting experiments, a typical one was the following.

A bright length of filament, tilted at a 45 degree angle, was seen with the left eye in one of the positions of one cross-bar of an X (say the bar extending from upper-left to lower-right); when the mechanical blinker closed off the left eye, and opened for the right eye, the filament was, in the interim turned so that it lay in the position of the other arm of an X. The filament thus rocked from one to the other of the X position while the shutters on the respective eyes were alternately opening and closing. He demonstrated that when the alternating blinking rate afforded about four

exposures per second, that any rocking effect was eliminated and what was perceived was a complete, steady cross.

Some of his findings were of this kind. With the shutter rate and screen-intensity constant, the clearest and most prolonged images were formed, (a) where there was bright light stimulating a small retinal area, at a stimulus rate of 8 per second, with a stimulus-to-rest ratio of 54:71 (e); (b) where there was a duller light stimulating a large retinal area, at a stimulus rate of 4 per second, with a stimulus-to-rest ratio of 50:200 (e).

Also, having devised an ingenious measure of immediate visual memory, he found, with some 40 subjects, a correlation between this and the durations of the after-images of approximately .60.

Throughout, he noted striking individual differences in durations of after-images, and in subjective colour experiences.

Some of his general conclusions:

> The intermittent stimulation of the whole retina plays a part in the arousal of the projected image, and --- the image can be formed in the absence of direct stimulation if the neighbouring parts of the retina be stimulated. (p. 426)
>
> (other experiments) seem to point to the fact that the conditions for producing the brightest projected image require the stimulation of a considerable portion of the retina, and the fact that the image can be obtained when there is no appreciable direct stimulation of the area originally excited ----- points to the fact that the whole retina is concerned in the formation of the projected image. (p. 426)

For further details the two original and fairly lengthy articles may be consulted.

BIBLIOGRAPHY

1. ADKINS, C.D., & LYERLY, S.B. Factor analysis of reasoning tests. Personnel Res. Section Rep. No. 878. Washington: Adjutant-General's Office.

2. ALLPORT, G.W. Personality. New York: Holt, 1937.

3. ALLPORT, G.W., & POSTMAN, L. The psychology of rumor. New York: Holt, 1947.

4. BOTZUM, W.A. A factorial study of the reasoning and closure factors. Psychometrika, 1951, 16, 361-386.

5. BRUNER, J.S., & GOODMAN, C.C. Value and need as organizing factors in perception. J. abnorm. soc. psychol., 1947, 42, 33-44.

6. CANTRIL, H. The psychology of social movements. New York: Wiley, 1941.

7. CATTELL, R.B. The riddle of perseveration. Person. J., 1946, 14, 229-267.

8. CATTELL, R.B., & TINER, L.G. The varieties of structural rigidity. Person. J., 1948, 17, 321-341.

9. ELLIS, W.D. A source book of gestalt psychology. London: Kegan Paul, Trench, Trubner, 1938.

10. FISHER, S. Patterns of personality rigidity and some of their determinants. Psychol. Monogr., 1950, 64, no. 1.

11. FUCHS, W. Untersuchungen uber das Sehen der Hemianopiker und Hemiamblyopiker. Zeitschr. f. Psychol., 1921, 86, 1-143. (Translated and condensed as Completion Phenomena in Hemianopic Vision, in Ellis (9) 1938).

12. GIBSON, J.J. The perception of the visual world. Cambridge: Riverside Press, 1950.

13. GOLDSTEIN, K. Concerning rigidity. Character and Pers., 1943, 11, 209-226.

14. GOTTSCHALDT, K. Uber den Einfluss der Erfahrung aud die Wahrnehmung von Figuren. Psychol. Forsch., 1926. 8, 261-317. (Translated and condensed as Gestalt Factors and Repetition, in Ellis (9) 1938).

15. GUILFORD, J.P., & LACEY, J.T. (Ed.). Printed classification tests, report no. 5. Army Air Forces Aviation Psychology Program research reports. Washington: U.S. Government Printing Office, 1947.

16. HARTMANN, G.W. Gestalt psychology. New York: Ronald Press, 1935.

17. HEBB, D.O. The organization of behavior. New York: Wiley, 1949.

18. HILGARD, E. Theories of learning. New York: Appleton-Century-Crofts, 1948.

19. JOHNSON, P. Statistical methods in research. New York: Prentice-Hall, 1949.

20. KOFFKA, K. The growth of the mind. London: Kegan Paul, Trench, Trubner, 1924.

21. KOFFKA, K. Principles of Gestalt psychology. New York: Harcourt, Brace, 1935.

22. KOHLER, W. Gestalt psychology. New York: Liveright, 1929.

23. KOHLER, W. The place of value in a world of facts. New York: Liveright, 1938.

24. KOHLER, W. Gestalt psychology. New York: Liveright, 1947.

25. KRECH, D., & CRUTCHFIELD, R.S. Theory and problems of social psychology. New York: McGraw-Hill, 1948.

26. LEEPER, R. A study of a neglected portion of the field of learning. J. genet. Psychol., 1935, 46, 41-75.

27. LEWIN, K. A dynamic theory of personality. New York: McGraw-Hill, 1935.

28. LUCHINS, A.S. The stimulus field in social psychology. Psychol. Rev., 1950, 57, 27-30.

29. LUCHINS, A.S. Proposed methods of studying rigidity in behavior. Person. J., 1947, 15, 242-246.

30. MILES, G.H. The formation of projected visual images by intermittent retinal stimulation. Brit. J. Psychol., 1915, 7, 420-433, 8, 93-126.

31. MOONEY, C.M. A factorial study of closure. Canad. J. Psychol., 1954, 8, 51-60.

32. MOONEY, C.M., & FERGUSON, G.A. A new closure test. Canad. J. Psychol., 1951, 5, 129-133.

33. MURPHY, G. Personality. New York: Harper, 1947.

34. NEWCOMB, T.M., & HARTLEY, E.L. Readings in social psychology. New York: Holt, 1947.

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

36. PEMBERTON, C. The closure factors related to temperament. J. Pers., 1952, 21, 159-175.

37. POSTMAN, L., & BRUNER, J.S. Hypothesis and the principle of closure: the effect of frequency and recency. J. Psychol., 1952, 33, 113-125.

38. SHEEHAN, M.R. A study of individual consistency in perceptual constancy. Arch. Psych., N.Y., 222.

39. SHERIF, M., & CANTRIL, H. The psychology of ego-involvements. New York: Wiley, 1947.

40. SPEARMAN, C., & JONES, LL.W. Human ability. London: MacMillan, 1950.

41. STREET, R.F. A gestalt completion test. New York: Teachers College, Columbia University Theses, No. 4, 1931.

42. THURSTONE, L.L. A factorial study of perception. Chicago: University of Chicago Press, 1944.

43. THURSTONE, L.L. Mechanical aptitude III, analysis of group tests. Chicago: University of Chicago Psychometric Laboratory, publication 55, 1949.

44. VERVILLE, E. The effect of emotional and motivational sets on the perception of incomplete figures. J. genet. Psychol., 1946, 69, 133-145.

45. VERVILLE, E., & CAMERON, N. Age and sex differences in the perception of incomplete pictures by adults. J. genet. Psychol., 1946, 68, 149-157.

46. WERT, J.E., NEIDT, C.O., & AHMANN, J.S. Statistical methods in educational and psychological research. New York: Appleton-Century-Crofts, 1954.

47. WERTHEIMER, M. Untersuchungen zer Lehre von der Gestalt. II Psychol. Forsch., 1923, 4, 301-350. (Translated and condensed as Laws of Organization in Perceptual Forms, in Ellis (9) 1938).

48. WERTHEIMER, M. Productive thinking. New York: Harper, 1945.

49. WOODWORTH, R.S. Experimental psychology. New York: Holt, 1938.

50. ZANGWILL, O.L. An introduction to modern psychology. London: Methuen, 1950.