The Relationship Existing Between Span of Perception and Voluntary Shift of Attention

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THE RELATIONSHIP EXISTING BETWEEN SPAN OF PERCEPTION
AND VOLUNTARY SHIFT OF ATTENTION

By

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. INTRODUCTION ...............................................................................</td>
<td>1</td>
</tr>
<tr>
<td>Modern Notions of Attention, Perception - Clarifications - Purpose of the Present Problem.</td>
<td></td>
</tr>
<tr>
<td>II. A HISTORICAL RESUME OF THE BACKGROUND AND RELATED LITERATURE ....</td>
<td>17</td>
</tr>
<tr>
<td>III. EXPERIMENTAL APPARATUS AND PROCEDURE ..................................</td>
<td>38</td>
</tr>
<tr>
<td>Subjects - Test I Span of Perception - Test II Voluntary Shift of Attention.</td>
<td></td>
</tr>
<tr>
<td>IV. RESULTS .....................................................................................</td>
<td>53</td>
</tr>
<tr>
<td>Scores; Test I and Test II - Correlations.</td>
<td></td>
</tr>
<tr>
<td>V. CONCLUSION ..................................................................................</td>
<td>72</td>
</tr>
<tr>
<td>BIBLIOGRAPHY ..................................................................................</td>
<td>81</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. SAMPLE SCORES FOR SPAN OF PERCEPTION COMPUTED BY MEANS OF THE CONSTANT STIMULI METHOD</td>
<td>47</td>
</tr>
<tr>
<td>II. TABLE OF INDIVIDUAL SCORES FOR SPAN OF PERCEPTION AND THE CORRESPONDING RATES OF VOLUNTARY SHIFT</td>
<td>57</td>
</tr>
<tr>
<td>III. SAMPLE COMPARISON BETWEEN SCORES FOR SPAN OF PERCEPTION FROM THE FIRST TEST AND FROM A RETEST</td>
<td>59</td>
</tr>
<tr>
<td>IV. HIGHEST AND LOWEST RATES OF FLUCTUATION OBTAINED FROM THIRTY-FOUR SUBJECTS</td>
<td>64</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURES</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 I L L U S T R A T I O N S O F S L I D E S 9 A N D 1 0</td>
<td>44</td>
</tr>
<tr>
<td>4 T H E N E C K E R C U B E</td>
<td>49</td>
</tr>
<tr>
<td>5 T H E S C R O Ë D E R S T A I R C A S E</td>
<td>49</td>
</tr>
</tbody>
</table>
CHAPTER I

INTRODUCTION

The experiment which is to be discussed in this paper deals with two distinct yet interrelated psychological subjects, namely, attention and perception. Some psychologists have even attempted to identify these two cognitive processes and freely interchange them, presuming that they are practically synonymous. For this reason a short explanation will be given here to each of the topics in order to clarify the meaning of attention and perception especially as referred to in this paper.

The subject of attention, particularly, has been the cause of much controversy. Attention demands the use of our rational faculties as distinguished from sense cognitive processes; it is also intimately connected with the will. Many modern psychologists, however, in their use of the term, disregard or do not admit its rational nature. One reason for this apparent confusion among the moderns, as to the actual meaning of attention, might be the difficulty entailed in accurately defining the term. Father Gruender has proposed a definition which will make clear what is meant here by attention. It is "... the voluntary or involuntary direction of
our mind toward one object of sense or thought, or definite group of such objects, to the more or less complete exclusion of all others.\textsuperscript{1} Attention may be sensory or rational depending on the processes which are involved, or the object toward which they are directed, or both. In the cognition of a sense object, attention is closely allied with sense perception; but when ideas are the objects of attention, or reason is invoked as a guide to any act, our intellectual processes are involved. However, in speaking of the separate operations of man's sensory and rational faculties, we do not mean to imply any division of the total substance of the mind. The mind operates as a whole, though one or another process may dominate.

That the intellectual processes are exercised in attention, may be understood more clearly by an introspective study of the act of attending. The following is an example of intellectual attention. Suppose that one has been asked a question, Is a priori reasoning the same as induction? The subject then tries to come to a decision. Before an assent or dissent is reached, introspection reveals that attention is focused on the relationship; comparisons and reasonings are made and finally, a judgment is reached. Images may and often do accompany the process. The attention, however, is directed primarily to the relationship between the two concepts. This

\begin{footnotesize}
\textsuperscript{1}Experimental Psychology, p. 217.
\end{footnotesize}
relationship is an abstract notion. Here, attention directs the rational faculties towards an object of the intellect; this is intellectual attention.

On the other hand, our attention may suddenly be attracted by a loud noise. Attention is involuntary and the object is one of sensory cognition. In this case we have an example of sensory attention. An animal may be said to attend to an object but not in the same sense as a man is said to attend, for the animal has no will to direct such powers, nor has he anything other than sensory cognition to be directed. His sensitive powers, however, suffice for him to be aware of an object presented to him; but, attention, taken to include voluntary direction of cognitive energy, is a power possessed solely by rational beings.

There are several psychological processes and products which are closely related to attention. Herein lies a source of error and confusion. Some of these other aspects have been designated by various psychologists as attention itself, that is, attention has been identified either with one of the determiners, one of the concomitants, or one of the effects of attention. Reflections on everyday experiences will clearly exemplify the many determiners of attention. It is usually the brightest light, the loudest noise, or the strongest odor which commands our attention. Advertisers sometimes emphasize the most important word on a billboard sign by printing it in
a brighter color than the rest of the words. In this way the "catchword" is intensified. Likewise in regard to sounds, even the loud rumble of the streetcar is forgotten by the passenger when a crash in the street draws his attention; so on through the numerous other common examples. In general, the most predominant sound, color, smell, etc., is the one which attracts most attention, and this predominance is the determiner of attention called intensity. Interest, too, though often an effect of attention, evokes attention. If we are interested in an occupation or task we will attend to it.

Two other factors are important determiners of attention: repetition and change. In musical compositions both are often used together as incentives for attention. The great composers used leitmotifs in their longer works, yet the leitmotif itself was presented each time in a different arrangement so that the variations, or change, would avoid monotony, and at the same time the theme phrase by its very repetition, would attract attention. Intensity, change, repetition, and similar factors are what we mean by determiners of attention.

An attitude of expectancy which is sometimes exteriorly expressed by a particular bodily posture or state of tension, is one of the frequent concomitants of attention. Some individuals manifest unique mannerisms when they are closely attending to an object or problem. These exterior expressions, too, are concomitants, certainly not attention itself as some psychologists claim.
Very important in the study of attention are the effects which it may produce. One of the most significant of them is interest, which, as mentioned above, may also be a determiner. It is a common occurrence among students that a once apparently distasteful task becomes one of interest after consistent attention has been given to it. Intensity, too, is another effect as well as a determiner of attention. Usually we are unaware of the feeling of our clothing, yet attention may make us very conscious not only of the pressure of cloth on our skin but even of a particular pricky or soft quality of the sensation. Clearness or distinctness is the result of focused attention. How different an object sometimes appears when we direct full attention to it. A casual glance at a picture might provide a hazy notion of the general outlines while full attention makes even the details clear. There are other effects, determiners, and concomitants of attention, but clearness and neuromuscular set are the two attributes most frequently confused with attention.

Titchener explains attention in terms of clearness.

It seems plain that the conditions of the attentive consciousness are of these two kinds. The clear processes, at the crest of the attention wave, are processes whose underlying excitations have been facilitated. Similarly, the obscure processes, at the lower level of consciousness, are processes whose underlying excitations have been inhibited. The attentive consciousness is thus conditioned upon
the interplay of cortical facilitation and cortical inhibition. \(^2\)

In one of his lectures on attention entitled "Attention as Sensory Clearness," Titchener summarizes the process of attention in terms of clearness. "Attention, in other words, means a redistribution of clearness in consciousness, the rise of some elements and the fall of others, with an accompanying total feeling of a characteristic kind." \(^3\) Such an explanation would fit well into the content psychology of the Structuralists, but certainly fails to explain the process of attention which is essentially an act of directing toward or selecting some object or situation. Certainly there is a significant relationship between clearness and attention since clearness in the perception of an object is increased proportionally to the increase of attention given to the object. But this very relationship would imply two different elements: one a mental process and the other an accompanying quality of the process; or one a cause and the other an effect. Besides clearness there are other qualities and effects brought about by this direction of our cognitive processes to an object. If we should define attention in terms of clearness, we might likewise define it in terms of intensity or sensory threshold, since these factors are also observable effects of attention.

\(^2\)A Text-Book of Psychology, p. 300.
\(^3\)Lectures on the Elementary Psychology of Feeling and Attention, p. 183.
would lead to further confusion and a total disregard for the actual meaning of attention as a mental act involving the higher thought processes as well as the sensory processes.

Attention is often accompanied by a particular bodily attitude or tonus, which in modern psychological terminology, is referred to as a bodily "set." Everyone has experienced this feeling of tenseness, this tightening of muscles, and even perhaps a constriction of facial muscles while attending to a difficult problem, or awaiting a signal to begin a timed test. This tenseness, or bodily set, seems to facilitate attention, and on the other hand, an over-relaxed posture or attitude at times hampers close attention. Some psychologists have defined attention as a type of neurological tonus, and have attempted to reduce this process, involving the rational faculties, to a particular type of muscular movement or constriction. Ribot, in his discussion of voluntary attention, completely resolves the process into a neurological activity.

These general considerations bring us, at least, to one positive result: namely, that every act of volition, whether impulsive or inhibitory, acts only upon muscles and through muscles; that any other conception is vague, incomprehensible, and chimerical; that consequently, if, as we maintain, the mechanism of attention is motor, then in all cases of attention there must necessarily be a play of muscular elements, real or
nascent movements, upon which the power of inhibition acts. We exercise no action (impelling or inhibitory) upon any other than voluntary muscles; such is our only and positive conception of will. Of two things, accordingly, one at least must be hit upon: either to find muscular elements in all manifestations of voluntary attention or else to abandon all explanation of its mechanisms and to limit ourselves to saying that it exists.\(^4\)

Another author indicates that evidences of set and muscular tonus substantiate the motor theory.

Our general experimental method is to be taken as one of the possible modes of attack upon the problems of 'set,' 'attitude' and other changes in performance produced by instruction habituation and the like. The results indicate that many of these problems, which have heretofore been approached solely from the theoretical and introspective angles, are capable of psycho-physiological attack. While they cannot be said to verify any particular hypothesis, they do provide evidence of the general fertility of the 'motor theory.'\(^5\)

In attempting to concentrate on a difficult philosophical problem or topic to be memorized, we notice that there is an

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\(^4\) *The Psychology of Attention*, p. 45.
attempt to direct our mental focus towards one item, and at the same time to keep out of consciousness any distracting element. This twofold attempt to focus on one thing and at the same time to avoid distractions is akin to the voluntary and involuntary types of attention which will be discussed in a later paragraph. McDougall explains this twofold process of inhibition and direction, rather naively, by a theory of "neural drainage."

Whether, then, we regard the process of turning the attention from one object to another from the point of view of the inhibition of one neural system by the other, or from one object to another from the point of view of the inhibition of one neural system by the other, or from the point of view of the establishment of a path of low resistance between them, the formation of a neural association we arrive at the same conclusion—the one system drains the other.  

It is interesting to note McDougall's footnote to this same quotation. "If this view should be found untenable we should be compelled to look for an explanation in some psychical guidance of the neural discharge."  

All these modern notions are defective because of a common, basic, and grave error, namely, the disregard of the

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6Physiological Psychology, p. 134.  
7Ibid., note.
rational element which is essential to the process of attention. Attention is the act of directing not only our sense cognitive processes but especially our intellectual cognitive processes to some specific object or situation. To define attention as clearness or neuromuscular set would be to define a rational process in terms of sense only. Harmon has enumerated five effects of attention: intensity, clearness, changes in sensory threshold, differences of reaction time, and interest. In criticizing the modern theories which would identify attention with some one of these effects or would define it as a neurological set, the author concisely rejects all such opposing arguments by saying, "Concomitance, it must be remembered, does not prove identity."

In the title of this thesis the word voluntary has been inserted to describe the particular type of attention shift dealt with in this experiment. Attention may be voluntary or involuntary. A sudden, loud noise sounded nearby attracts our attention whether we will it or not; often a particular train of thought or a tuneful melody persists in drawing our attention even though we repeatedly attempt to discard it from consciousness. In fixating upon an ambiguous figure an individual will notice shifts in position without any effort on his own part to bring about the shifts. On the other hand, these shifts

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8Principles of Psychology, p. 270.
can be accelerated by voluntary attention and, as will be seen in a later chapter, some individuals have a greater facility in voluntary shift of attention than others. Though, with preliminary practice, improvement is shown by all individuals, if given a definite time, there is a noticeable variability among subjects in this capacity for shifting of attention. Each one seems to have a more or less characteristic rate for shifting any figure, though the rate may vary for different figures.

In the voluntary oscillations of ambiguous figures the positive and negative aspects of the will are especially evident. The positive aspect is indicated in the subject's attempt to shift the figure's position, in which attempt he must exert considerable effort to see the desired position; the negative aspect is indicated in his endeavor to reject the position which is present at the time. Here, introspection reveals a veritable antagonistic mental "pull" between the positive and negative efforts; a similar "pull" may even be felt in the accompanying neuromuscular activities. It is this very "mental pull" which offers the most convincing evidence that two kinds of attention exist, voluntary and involuntary. In involuntary attention we seem to attend without any noticeable exertion, while in voluntary attention, the efforts of the will, both negative and positive, are undoubtedly in operation.
The completeness of control over our own thoughts, the success with which we can command in the expulsion or detention of a particular mental state, varies at different times and in regard to different objects. A representation of the imagination, a strong emotion, a worrying train of thought, no less than some distracting external stimulus, may at times render nugatory repeated efforts to apply our mind to some other topic. It is this experience of resistance which affords us the most convincing assurance that we have a real power of free voluntary attention for it reveals to us in the clearest manner the difference between automatically drifting with and actively struggling against the natural current of thought. 9

This experience of resistance and power of voluntary shift of attention are likewise noticeable in working with ambiguous figures, more objectively, perhaps, than in thought alone.

Even in regard to voluntary shift of attention, physiological factors are ever present and influential. In this particular type of experiment, using the ambiguous figures, the rate of shift reaches a maximum after a few minutes of steady attention, usually three or four, and then a decrease follows due to fatigue. In any task which requires prolonged attention, fatigue and general physical condition of the individual are

important factors and may alter the results to a considerable extent.

Subjects have been found to vary considerably with regard to the rate at which any given figure appears to shift; and this in itself is convincing, though not necessarily conclusive evidence of physiological influences. It is possible, moreover, to show that such conditions as fatigue, loss of sleep, and drugs affect the rate of change in ambiguous figures; all of which points to the significance of organic processes as regulatory factors at least.10

Span of perception is closely allied to this subject of attention since it is evident that an individual’s span of perception varies greatly with the amount of attention given to a task by the observer. If the individual, while attempting to perceive the contents of a card presented tachistoscopically, allows his attention to wander, the results of such an experiment will differ considerably from those obtained in a like trial wherein full attention was given to the task. In brief, attention is an important and partly controllable variable in any experiment on span of perception.

The tachistoscopic experiments have aroused the old question of whether or not one can attend to more than one thing simultaneously. Here perception aids attention; for if perception can synthesize the material presented into some type of

10 Francis L. Harmon, Principles of Psychology, p. 223.
organization, the amount of material to which one can attend in one instant will be increased. This perceptive ability to organize amounts of material into a unity or whole which can be grasped immediately varies to a certain extent in different individuals, though there is an average range which can be perceived by adults. This average range, in turn, varies according to the type of material. For example, a larger group of related words can be perceived at one exposure on the tachistoscope than can a group of nonsense words; more letters can be perceived when these letters can be grouped into syllables or words than if presented as isolated letters. Span of perception also depends on the amount of information demanded. A. D. Glanville and Karl M. Dallenbach performed an experiment in order to determine the average span for various types of material. They found that the span followed this order: greatest for number of dots, less broad for letters, geometrical forms, and, finally, least for reports on both form and color.¹¹

Span of perception is also relevant to reading ability. A person with a broad span is able to read more rapidly since his span includes more words in one fixation. Likewise, when fewer fixations occur less time is required for the perusal of

each line. The slow reader is often the one who has been accustomed to reading one word at a time rather than grasping a group of words or a phrase by one fixation. Individuals who lip read also tend to apprehend but one word at a time rather than a group of consecutive words. Here again efficient reading is impeded. In studying the eye movements during reading and study, investigators found, "... the most rapid readers as a rule show the most extensive perception span."12

Do any of these examples actually answer the question concerning the ability to attend to more than one thing at a time? Strictly speaking, it would seem that one is unable to attend to more than one thing at a time. In experiments where subjects are given two tasks to perform at once, the usual results show a rapid fluctuation from one task to the other rather than a constant and simultaneous attention to both. However, before answering such a question, a clear differentiation between the terms attention and perception as well as between intellection and sensory perception would be necessary. In considering the disputes and literature written on this problem throughout the centuries, one notices the very loose use of such terms as "attending to," "perceiving several objects at a time," and "knowing or understanding wholes." It should be remembered that perception may directly synthesize the various parts or qualities of an object, while attention more properly directs the cognitive processes of whatever sort to

the object. It is not the purpose of the present investigation to answer the question of the possibility of simultaneously attending to more than one object. Yet we cannot fail to notice that there is a relationship between the factors involved in our experiment and those in the multiple-attention investigations.

These are but a few of the many aspects to two important psychological subjects, namely, span of perception and attention. In the present experiment the writer raised the question of the possibility that a relationship existed between the ability to voluntarily shift attention and the ability to take in a large number of objects in the span of perception. The problem was to discover by means of experimentation whether or not individuals with broad spans showed greater facility to voluntarily shift attention and whether or not those having narrower spans likewise showed less facility in the same performance.
CHAPTER II

A HISTORICAL RESUME OF THE BACKGROUND AND RELATED LITERATURE

The history of the present problem dates back to the time of Aristotle and the early Greek and Roman writers. As mentioned in the previous chapter, the problem of attention was a controversial topic of old standing, and these controversies led in time to the origin of the tachistoscope, which is now used to measure breadth of perception. This instrument and the origin of its present use is of particular interest in this paper since the first part of the experiment is concerned with span of perception obtained by means of a tachistoscope. In the following pages I shall not attempt to discuss all the problems connected with attention or to answer the question regarding the possibility of attending to more than one object at a time. I shall merely present a brief survey of the background literature on attention and perception, especially of the works which closely pertain to the present experiment.

Aristotle, in speaking of sense and sensible objects, was confronted with the difficulty of perception and probably was the first to propose the question, Can two things be perceived simultaneously? He concluded that this would be impossible
unless the objects were in some manner synthesized.

... it is not possible to perceive two objects with one sense, unless they are amalgamated; for the amalgamation tends to make one whole, and there is one sensation of the unit and this one sensation coincides with itself. So that there is necessarily simultaneous perception of the objects amalgamated, because the soul actually perceives with one sensation; for the sensation which is actually a unit is of something numerically also a unit, but, of one object only in species, the faculty is only potentially a unit. Whereas if the faculty is actually one, it will call its objects one. And so they must be amalgamated. When they are not amalgamated, the actual sensations will be two. But in the case of a single faculty in an indivisible moment of time, the activity must be single; for the movement and employment of one faculty at a single instant implies that the activity is one, and the faculty in this case is only one. It is not then possible to perceive two objects with a single sensation.\(^1\)

If Aristotle was consulted as to the exposures of figures on the tachistoscope, he might respond that the dots gave rise to only one sensation since they were perceived as a numerical

whole. However, such an answer might not suffice or satisfy modern investigators in regard to the apparent immediate perception of several different figures.

Quintilian argued differently when orating about the training of young boys. He strongly refuted the prevailing notion of his day that boys should be limited in the number of their studies and devote their time to only a few things at once, lest they overburden their strength. Quintilian exhorts the elders to a contrary mode of action, advising a variety of occupations and duties, and, while doing so, proffers his viewpoint on attention. He criticizes those who would so limit the diversity of subjects in the curriculum.

These critics show an insufficient appreciation of the capacities of the human mind, which is so swift and nimble and versatile, that it cannot be restricted to doing one thing only, but insists on devoting its attention to several different subjects not merely in one day, but actually at one and the same time. Do not harpists simultaneously exert the memory and pay attention to the tone and inflexions of the voice while the right hand runs over certain strings and the left plucks, stops or releases others, and even the foot is employed in beating time, all these actions being performed at the same moment? Again, do not we ourselves, when unexpectedly called upon to plead, speak while we are thinking what we are to say next,
invention of argument, choice of
words, rhythm, gesture, delivery,
facial expression and movement all
being required simultaneously.2

It is obvious here that Quintilian was not analyzing the problem of attention from a psychological point of view. The examples given demonstrated a diversity of actions which indicated either great facility in shifting rapidly from one to the other, or fully formed complex patterns of movement. They did not exemplify simultaneous perception of many single objects or attention directed to several separate things at one and the same time. Skill in such movements as is required by the harpist enables the performer to shift so rapidly from one to the other that, to the casual observer, the activities may apparently be operating simultaneously. It often happens, too, in such skilled movements, that some become more or less automatic and may continue for a considerable period of time before the individual again reverts his attention to the task.

St. Thomas seems to agree with the philosophers who state that the mind does not attend to more than one thing at a time in the strict sense of the word. To the objections given on the grounds that the intellect understands at the same time a whole which contains parts, such as house or man, St. Thomas replies:

Parts can be understood in two ways. First, in a confused way,

as existing in the whole, and thus they are known through the one form of the whole, and so are known together. In another way they are known distinctly; thus each is known by its species; and so they are not understood at the same time.

While Aristotle discusses the problem from the aspect of sense perception, St. Thomas refers to it in terms of intellectual perception. Hence, we really have two problems, two distinct but interrelated interpretations. Does attending to more than one thing at a time signify the same as visually perceiving two objects simultaneously? In the comments of the various philosophers there is reference at one time to intellect and at another time to sense perception; thus the confusion is increased.

Abraham Tucker, a philosopher of the eighteenth century and a psychologist as well, in treating of knowledge and conception refers to the calculations of numbers, and in doing so, mentions a few points relevant to the problem of attention.

Number itself, whereon we can reason with the greatest accuracy and certainty of any subject, quickly exceeds our comprehension; it is a question with me whether we have a direct idea of any more than four, because beyond that little number we cannot tell how many objects

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lie before us upon inspection, without counting. Higher numbers we cannot ascertain unless when ranging them in order, which compounds the individuals into parcels, and thereby reduces them to fewer ideas, we can bring them within the compass of our apprehension; therefore we can presently reckon nine disposed into three equal rows, because then we need only consider them as three threes. 4

Sir William Hamilton, in his lectures on attention, remarked that many other philosophers of the Middle Ages disputed the question, and from his works we can ascertain a cursory estimation of the outstanding participants.

The modern philosophers who have agitated this question, are not aware that it was once canvassed likewise in the schools of the middle ages. It was there expressed by the proposition, Positne intellectus noster plura simul intellegere. Maintaining the negative we find St. Thomas, Cajetanus, Ferrariensis, Capreolus, Hervaeus, Alexander Alensis, Albertus Magnus and Durandus; while the affirmative was asserted by Scotus, Occam, Gregorius Ariminensis, Lichetus, Marsilius, Biel and others.5

The controversy passed back and forth among the philosophers and then from one century to another without any final agree-

ment having been attained at any time. Perhaps this may lend encouragement to the modern psychologists who have so far failed to solve adequately or fully explain the problem so as to arrive at a decision acceptable by all. Glanville and Dallenbach mention some of the moderns who have participated in the polemics on the subject and who have carried down the schism to our own era.

The Scholastics were divided upon the question as were also the philosophers following them. Hobbes, Locke, Wolff, Stewart and Brown, for example, held to the Aristotelian doctrine, whereas Leibnitz, Tucker, Bonnet and Destutt de Tracy opposed it.6

Variances in the use of terms have already been evident in the passages quoted and we see again in the following statement that among the moderns, too, some speak of thought, others merely of visual perception. This divergence of meanings, as regards the problem in question, is exemplified again in Stout's remark, "... however manifold or heterogeneous the objects of my thought may be, I must, in thinking of them, simultaneously think of some relation between them."7 As in the case of most disputes a clarification of terms sometimes greatly simplifies the solution, and ambiguity of meanings has oftentimes been the source of prolonged philosophical dissen-

sions. Father Maher points to this failure of distinction in terms as a probable source of the disagreement. "Whether we can attend simultaneously to more than one object has been much disputed; and as is usual in such cases, the disputants often differ as to what they mean by 'attend' and 'one object.'"8

In the discussions on this dispute a comment particularly pertinent to the present experiment has been made by Father Moore. I say it is particularly pertinent because it deals specifically with visual perception.

We may think that we take in a whole picture and all its parts at once, but we do not. There are two principles to be borne in mind here which are involved in every process of perception. 1. The perception of geometrical and other simple figures is a process of building up details in which one usually proceeds from the general till he comes to the particular and finally to the orientation of part to part in the objective presentation.

2. Only one thing is perceived at a time. Even the perception of dots (one, two, three dots, etc.) goes on by a regular law so that it takes longer to perceive two dots than one, three than two, etc.9

This assumption would imply, then, that the dots perceived on the slide of a tachistoscope are not perceived simultaneously.

8Psychology: Empirical and Rational, p. 349.
9Cognitive Psychology, p. 250.
This author attributed a new interpretation to the age-old question which would perhaps alter the answer. How many different things one may be conscious of, and how many different things one may actually attend to, are two separate questions. Each requires a separate explanation. Another modern psychologist refers to the time element involved. "The number of separate objects that can be attended to is four or five for vision . . . But probably this result is to be interpreted to mean that the result of a single glance persists long enough for four or five acts of attention to take place."

In another work the same author says, "Attention changes from one to the other just often enough to keep the different processes going."

Before discussing the recent literature and experiments relevant to our present experiment, it will be worthwhile to trace the origin of the tachistoscopic method. It was the same problem of attention, the same dispute as to whether or not one can attend to more than one thing at a time, that occasioned the first attempt at using this method; an informal and rather crude experiment constitutes the original precursor of the modern tachistoscopic experiment. Sir William Hamilton, in one of his lectures on attention, was explaining to his students the principle of focality; it states that the more units among

12 W. B. Pillsbury, Attention, p. 83.
which the attention is distributed, the less clear will be the
cognizance of each. He then raised the familiar question, how
many objects might be perceived simultaneously by the mind,
and proposed the following simple experiment to his subjects.

If you throw a handful of marbles
on the floor, you will find it
difficult to view at once more
than six or seven at most without
confusion; or if you group them
into twos or threes, or fives,
you can comprehend as many groups
as you can units; because the
mind considers these groups only
as units—it views them as wholes
and throws their parts out of
consideration.14

Inaccurate because of the lack of preciseness in method, such
an experiment could provide only a rough estimate; nevertheless,
the underlying principle is the same as in our modern tachis-
toscopic experiments.

Considerable progress was made by the next experiment of
this type which was performed by W. Stanley Jevons in an at-
tempt to answer for himself the disputed issue. He devised a
round paper box 4 1/2 inches in diameter, lined with white paper
and with edges cut down which would make the box stand about
1/4 inch high when placed on a black tray. He procured a quantity
of uniform black beans and then took up a handful and threw
them towards the box so that any number of them fell into it.
As soon as the beans came to rest he immediately estimated the

number and recorded it together with the actual number in the box. The following are the results obtained by Jevons from 1,027 trials.¹⁵

<table>
<thead>
<tr>
<th>Number of beans</th>
<th>Per cent of correct judgments</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>96</td>
</tr>
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<td>6</td>
<td>82</td>
</tr>
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<td>7</td>
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<td>8</td>
<td>56</td>
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<td>9</td>
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<td>10</td>
<td>43</td>
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<td>11</td>
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<td>13</td>
<td>23</td>
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<tr>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>15</td>
<td>18</td>
</tr>
</tbody>
</table>

Jevons made a significant statement in regard to his experiment, a statement upon which the very principle of the tachistoscope is based, namely, the time element by which the exposures are so regulated as not to permit any shift in the fixation of the eyes. "The whole value of the experiment turns upon the rapidity of the estimation, for if we can really count 5 or 6 by a single mental act, we ought to be able to do it unerringly at the first momentary glance . . ."¹⁶ While Jevons depended on a swift, momentary glance, he realized that the experiment depended on the briefness of this glance. Thus the

¹⁶Ibid., p. 281.
tachistoscope came to be used, though it was first employed not to see how much one could perceive in one fixation, but to see, "... how brief a stimulus could arouse visual sensation." The word itself comes from the Greek word tachistos, which is the superlative of swift, plus the word scope.

One of the earliest attempts to control the time allotted for perception and thus accurately limit the exposure was made by James McKeen Cattell, who used a gravity chronometer for the purpose. He conducted several experiments in the first of which short perpendicular lines, 2 mm. apart were printed on a card and allowed to be seen for .01s. Eleven cards containing from four to fifteen lines were used on eight persons. The following gives a few of the conclusions arrived at by Cattell.

... it was found that two could judge the number of lines correctly up to six, two up to five, three four, and one not four. This gives the number of simple impressions consciousness can at one time attend to ... Practice does not seem to improve the accuracy of the judgment ... on an average, consciousness can at one time grasp four numbers, three to four letters, two words, or a sentence composed of four words.  

Hylan in 1903 found in his tests that from four to five objects

---

could be perceived at once on the tachistoscope and six was considered the extreme limit; he also found that these numbers were greatly increased when letters were used and still more so when these letters were grouped into meaningful syllables or words. On the discovery of the latter, Hylan decided that it was not possible to elicit a satisfactory explanation from such varied results.

Unfortunately we are without an explanation of the limit of this multiple activity of the attention, so that little satisfaction could be given one who should ask why ten or a dozen objects should not be simultaneously attended to as well as four or five.19

From Cattell's time down to the present many modifications and various types of improved tachistoscopes have been invented to measure span of perception.

The recent experiments on span of perception and the corresponding topic of attention are treated from numerous and various aspects, and I will therefore refer to a few of the more pertinent ones. Chapman and Brown studied span in relation to the prominence of any individual content in the material presented. For example, they presented several series of letters and in each series made one letter more conspicuous than the others by centering its position, enlarging its size, 

and changing its color. Their results were found to agree with Kulpe's principle which states: "The greater the range of attention, the lower is the degree of consciousness attaching to any individual content; while vice versa, the number of objects grasped by attention decreases as concentration upon any one of them increases." This principle was ably demonstrated too in Father Moore's doctoral thesis. In his experiment a series of geometrical figures were exposed on a rotating disk for a quarter of a second. Five figures were presented on each exposure and in each group a figure common to all other groups was present, though its position changed upon every presentation. The subjects at the end of the experiment were asked to draw the figures they had seen. The results obtained clearly showed that the more prominent the common figure was in consciousness the more obliterated were the other figures. The following are the percentages of figures remembered; the results are given for three subjects.

<table>
<thead>
<tr>
<th>Common element seen</th>
<th>Common element not seen</th>
</tr>
</thead>
<tbody>
<tr>
<td>- - - - - - - - - -</td>
<td>10.5</td>
</tr>
<tr>
<td>- - - - - - - - - -</td>
<td>22.0</td>
</tr>
<tr>
<td>- - - - - - - - - -</td>
<td>14.0</td>
</tr>
</tbody>
</table>

In planning an experiment to test span of perception it is evi-

ident that the material used must be carefully prepared so that the letters, digits, or words, be equal in position, size, etc. For this very reason, dots or rings presented on a slide are much more uniform than either letters or numbers and will lend themselves to a more accurate test of visual span.

Glanville, Dallenbach, Fernberger, Oberly, Gill and others have all performed experiments on span of perception using white cards with black dots and exposing them by means of a tachistoscope. One of the most interesting experiments of this group was the work done by Sherman Oberly. He attempted to determine the span of perception for his subjects by three different methods which he designated as span of attention, span of cognition, and span of apprehension. In the first, the subjects were limited to an immediate perception of dots which were equally clear; in the second, the same subjects were permitted to group and this was to indicate varying degrees of clearness, though no subsequent time was permitted for further calculation of dots apprehended; in the third test, these subjects were permitted to count, group, or attain their estimation by any means and were allowed time subsequent to the exposure before giving a judgment. The average spans obtained by these methods were as follows:22

1. Attention — 3.93 dots
2. Cognition — 6.91 dots
3. Apprehension — 8.21 dots

The distinctions which the author makes between the method used in attention and that used in cognition is not very clear, since he does not say how he stopped his subjects from grouping. However, the method of apprehension, wherein neither subsequent time nor tendency to group was restricted, is the ordinary method used to gauge span of perception. This latter method was used in the present experiment.

The factors of voluntary and involuntary attention have been studied, especially in more recent times, by means of figures with reversible perspective. With ambiguous figures one can observe both involuntary and voluntary shifts of attention. Although the figures reverse themselves, without any attempt whatsoever on the part of the subject, the direction of attention to these shifts noticeably influences the rate of such shifts. Flugel performed a series of these tests and from their results, together with the introspective reports of his subjects, came to the following conclusion.

The nature of the perspective in which a reversible figure is seen at any moment is— at any rate, mainly dependent upon the direction of the attention; and this dependence of the perspective upon the attention is of such a kind that . . . . those parts which receive the more
attention are seen in front of those which receive the less attention. ... 23

The rates of attention shifts have likewise followed the modern trend in psychology which attempts to interpret various psychological data in terms of personality traits. McDougall performed experimental tests on mentally diseased patients and proposed a theory of introversion-extroversion personality types. His theory based the difference of personality partly upon rate of fluctuation of attention on an ambiguous figure. E. Louise Porter, in a doctoral thesis on factors in fluctuation, made a comparative study of fluctuation rates, obtained on several ambiguous figures, and the scores on introversion-extroversion traits obtained from the Nebraska Personality Test given to the same subjects. This author, however, studied only involuntary fluctuations as her directions indicate. "Sit comfortably close to the table and assume a passive attitude. Keep your eyes on the figure as a whole and do not stare. Let the phases come and go freely without trying to hold or hurry them." 24 The author summarized the results and gives the following data regarding fluctuation rates and personality:

The rates of fluctuation are highly reliable measures of one attribute of an individual. That an individual with a more rapid fluctuation rate tends to be more socially introverted as measured.

by the Nebraska Personality Inventory.25

Fredrickson and Guilford, however, in attempting to find a similar correlation, found that their results gave very little foundation for a positive relationship between introversion traits and rate of fluctuation. Two of their conclusions are significant in this regard.

1. The results of previous experiments which indicate that the rate of fluctuation of an ambiguous figure cannot be used as an objective test of introversion-extroversion are verified by this test.

4. It is clear that no group factors residing in the typical test of introversion-extroversion bear any significant relationship to fluctuation rate, since no single items correlate with rate.25

Closely allied to voluntary shift of attention is the mental tendency called perseveration. Most notable of the tests devised for rating perseveration are those of R. B. Cattell. In these tests the subjects are told to write a series of letters or figures as rapidly as they can but with care in formation of the letters; such letters as S or Z are used and then the subjects are made to write the same letter inverted for a

certain period of time; in the third trial, the subject is required to write the letter forward and then reversed, continuing in this order as rapidly as possible. Invertible figures are used in the same way as the letter. Cattell has correlated personality traits with the results of these tests and in doing so lists the traits in the order of reliability. The extremely low perseverate was found to be characterized by vitality, tenseness, capacity for great industry, and continuous work at high pressure; the extremely high perseverate was found to be a languid, slow, and desultory worker, quiet and sensitive. Many other traits were listed by the author in a descending order of reliability.27

Using similar perseveration tests, Father J.L. King, S.J. performed an experiment on a group of subjects and made a comparison between the results obtained, and the span of perception found for each of the same subjects. Father King found that those having a wider span tended to be low perseverates while those whose span was smaller tended to be high perseverates.28 On reflection upon the results of this experiment it was argued that the high perseverate would have lesser ability to shift attention voluntarily, since his tendency to persist in any activity in which he was engaged at any moment was

relatively great. Hence we decided to raise the question regarding the existence of a correlation between shift of voluntary attention and breadth of span.

These are but a sampling of the experiments and related literature, recent and otherwise, which have concerned span of perception and the various aspects of voluntary attention. In this experiment no attempt was made to make a comparative study between personality traits and either span of perception or fluctuation of attention. The purpose was merely to investigate the possibility of an existing correlation between span of perception and the rate of voluntary shift of attention.
CHAPTER III

EXPERIMENTAL APPARATUS AND PROCEDURE

The experiment consisted of two separate tests; the first was given to determine the individual's span of perception for rings, presented by means of our projection tachistoscope; the second, to determine the rate per minute of voluntary shift of attention by means of ambiguous figures. The two series of tests were administered individually to all of the subjects in two sittings over a period of time covering about three months. The subjects were all adults unacquainted with laboratory procedures but most of whom were of college level. Scores were recorded for thirty-four subjects; twelve psychology students were tentatively used as preliminary subjects, but since they are not a representative sample of the general population owing to laboratory experience, their scores are not included in our correlations. Since the apparatus and procedures are entirely different for each series of tests we will discuss them under two separate headings.

Experiment I

The first series of tests were those administered for the purpose of determining each subject's span of perception for
dots or rings. Woodworth enumerates a few requisites for a
good tachistoscope.

A good set up provides a pre-

exposure field of about the same
brightness as the exposure field
itself, so that the eyes are
properly adapted in advance. A
visible fixation point enables
O to look in the right direction;
and this fixation mark is prac-
tically at the same distance as
the objects to be exposed, so
that O's eyes are properly fo-
cused and converged in advance.
These are the elementary conditions
of a good tachistoscope.1

In arranging the apparatus for our experiment we endeavored to
fulfill these elementary conditions. The room used for the
tests was darkened and used only in late afternoons and eve-
nings of the winter season and only at night during the later
months so as to give greater assurance of a sufficiently dark-
ened room. The machine itself consisted of an S.V.E. Projection
lantern equipped with a camera shutter and short focus lens for
near work; it was constructed especially for the present expe-
riment. The camera shutter regulated the time for each expo-
sure at 120 milliseconds (standard deviation for 40 measured
trials, 7 milliseconds), and thus eliminated the possibility
of change of fixation in any one exposure. This length of time
permitted a clear view of the slide and yet was short enough

1Experimental Psychology, p. 688.
to prevent the subject from getting two views. A further advantage of the camera-shutter type of tachistoscope was the minimum amount of noise accompanying each presentation, since no more than a camera click was necessary for the exposures. The machine is a handy and compact one, measuring fourteen inches in length, four inches in width, and standing seven and one-half inches high from the table.

The apparatus was placed on a table of convenient height for the subjects; the screen was situated on another table of equal height and was placed at a distance of 28 inches from the end of the projection lens so that the slides might be in focus on the screen. A piece of cardboard 11 x 8½ inches covered with white paper in front and held vertically by an easel served as the screen. A vertical line and a horizontal line were drawn in pencil lightly across the center of the screen; the point of intersection was the point for fixation. The lines were drawn lightly enough so as not to interfere with the exposures of the rings and yet visible enough for the subjects to fixate with ease. Behind the screen was placed a shaded lamp which stood a little lower than the ordinary floor lamp. The lamp was so situated as to afford sufficient illumination for the visibility of the fixation point and yet permitted the general field to be dark enough for clear exposures. Thus the pre-exposure field provided proper adaptation for the eyes. The lantern itself contained a 30-watt lamp for screen illumi-
nation and was conveniently supplied with a push-through switch in the connecting cord, and within handy reach for the experimenter. The subject was comfortably seated in a chair beside and a little to the front of the slide holder of the apparatus, 36 inches from the point of fixation.

Glass slides 2 inches x 2 inches were especially prepared for this experiment. Black rings were impressed on pieces of thin cellophane by means of a typewriter; the small letter o was used. The rings were distributed in haphazard fashion on the cellophane and placed between the two squares of glass which were then taped together. The center section of the slides, which contained the circles, was rectangular in shape. Thus four different positions could be used for each slide. The rings were used in place of dots so as to avoid after-images from the exposure. Figure 2 and 3 illustrate four of the slides as they appeared when projected on the screen.

Before each experiment the distance between the subject and point of fixation was measured and the shaded lamp adjusted so as to accommodate the visibility of the fixation point for each individual. The machine was likewise briefly tested to assure the experimenter that the slides were in focus.

The experimenter attempted to put the subject at ease by telling him that the purpose of the experiment was not to test his mental abilities but merely to see how many rings he could see for the short time of exposure. He was encouraged, how-
Figure 2
ever, to attend closely and to do his very best. The following instructions were given to each subject:

The screen which is placed before you has two lines which intersect in the middle of the paper. The point where they intersect is the point at which you are to fixate your eyes when given the ready signal. Do not focus in between exposures lest you fatigue your eyes. The slides which I am going to present will have circles on them and will be shown on the screen for a fraction of a second. After each exposure I will ask you to report the number you saw; if you are not quite certain or do not know simply say, I'm not sure, or I do not know. Before each exposure I will say "ready," which is the signal for you to fixate on the point in the center of the screen, and I will then flash the slide on the screen.

These instructions were given at least twice to each subject and more often if necessary. The subjects were all given a few preliminary trials to acquaint them with the procedure. After the preliminary trials the slides were presented according to the above directions and in random order according to the rules for the Constant Stimuli Method. To avoid recognition of any one pattern upon subsequent presentations the slides were inverted in alternate presentations. The answers were marked on a score sheet either as correct, incorrect, or uncertain. From time to time the subject was asked if he was fatigued, and if so, was permitted a few minutes rest. The
percentage of correct judgments was then calculated for each slide and the mean of transition for all of the presentations to each subject. Table I shows the percentages of trials correct for each slide and the span obtained by the summation formula for a few representative subjects. These sample records were chosen from the group of thirty-four subjects as showing a wide range of scores for span as well as individual differences in the size of the zone of uncertainty.

Let us recall that in Oberly's experiment three different methods were used for obtaining the span of dots for each subject. These methods were called span for attention, cognition, and apprehension, respectively. The first method limited the subject to an immediate perception; in the second method the subjects were permitted to group but allowed no subsequent time before giving a judgment; in the third method, the subjects were permitted to count or group in order to form an estimation and subsequent time for the report was also allowed. Oberly's subjects were trained in laboratory procedures and

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### Table I

Range of Scores for Four Subjects

<table>
<thead>
<tr>
<th>Number of Rings Presented</th>
<th>Percentages of Correct Judgments</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subject Bk.</td>
<td>Subject Ad.</td>
<td>Subject Ls.</td>
<td>Subject Ms.</td>
</tr>
<tr>
<td>4</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
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<tr>
<td>5</td>
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<td>1.00</td>
<td>1.00</td>
<td>0.80</td>
</tr>
<tr>
<td>6</td>
<td>1.00</td>
<td>0.92</td>
<td>1.00</td>
<td>0.50</td>
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<td>7</td>
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<td>0.75</td>
<td>0.844</td>
<td>0.363</td>
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<td>8</td>
<td>1.00</td>
<td>0.421</td>
<td>0.923</td>
<td>0.23</td>
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<tr>
<td>9</td>
<td>0.846</td>
<td>0.373</td>
<td>0.562</td>
<td>0.20</td>
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<tr>
<td>10</td>
<td>0.633</td>
<td>0.33</td>
<td>0.583</td>
<td>0.00</td>
</tr>
<tr>
<td>11</td>
<td>0.428</td>
<td>0.11</td>
<td>0.10</td>
<td>0.00</td>
</tr>
<tr>
<td>12</td>
<td>0.437</td>
<td>0.00</td>
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<td>13</td>
<td>0.250</td>
<td>0.00</td>
<td>0.11</td>
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<td>14</td>
<td>0.00</td>
<td>0.00</td>
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<td>15</td>
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<td>0.00</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td><strong>Span of Perception</strong></td>
<td><strong>11.09</strong></td>
<td><strong>8.4</strong></td>
<td><strong>9.8</strong></td>
<td><strong>6.5</strong></td>
</tr>
</tbody>
</table>
introspective methods. Since our interest lay chiefly in getting the naive and spontaneous response of untrained subjects, the last of these methods, namely, span of apprehension, was the method used in our experiment. The subject was permitted to count or group and ascertain the number of dots by whatever means he chose. All our subjects were inexperienced in laboratory methods, and hence no directions were given as to methods of apprehension, but they were merely asked to report as nearly as they could the number of rings which they had seen. All of the subjects, however, reported afterwards that they had used both grouping and counting and they did so according to the relative difficulty of the slides for each person. In other words, those with larger spans could perceive the slides with 4 and 5 and sometimes 6 rings without any counting or grouping, while those with narrower spans grouped even the four and five ring slides.

Experiment II

The materials for Experiment II were comparatively simple and consisted of two drawings of ambiguous figures, one of the Necker outline cube and the other a drawing of the Schröder
Staircase. The outline cube was the figure used for the preliminary practice period and the Schröder Staircase for the experiment itself.

The preliminary practice period constituted a very important part of the test and was particularly revealing, because the subject could speak freely about his experiences with the cube while trying to shift its position. He could tell what methods he was using in attempting to shift it, and could add whatever else he might have to offer in the way of introspective data.

Before giving the instructions, the subjects were asked if they knew what an ambiguous figure was, and if not, the nature of the figure was explained. A drawing of one of the simpler ones such as the urn, or the duck-rabbit figure, was shown by way of example along with the explanation.

The subject was seated comfortably at a table in a position which provided the best illumination. The following instructions were then given.
to the subject:

I am going to present to you some ambiguous figures, the first one of which will be a cube. Look at it steadily for a few seconds and you will notice that its position shifts. I want you to try to shift the cube to different positions back and forth as fast as you can and to do so until you feel that you can make it shift no faster. Do this until you are fatigued. After a short rest I will give you a picture of a staircase. Try to shift this figure as fast as you can. After a short preliminary trial I will begin to record the shifts you make on the staircase. I will give you five trials with short rest periods between each one. At the beginning of each trial I will say "get ready, begin." You start reporting the shifts when I say, "begin" and stop when I say, "time." Report each shift by saying "now, now," etc. Do not look at the figure during the intermissions but rest your eyes.

These instructions were read as often as was necessary and any further questions of the subjects were answered.

In the preliminary practice period the subjects attempted to gain facility in shifting the cube from one position to another. This period usually lasted from five to seven minutes, in a few cases a little longer. When the subject reported the shifts in a regular manner, that is, when the reports "now, now," etc., assumed a more or less rhythmical rate, the subject soon reported that he was shifting as rapidly as he pos-
sibly could. The subjects were encouraged to continue practicing until they had attained a regular rate of shifts whatever that rate might have been. This is an important point in the preliminary practice period. In the case of some of the practice subjects, before the present procedure was definitely outlined, those subjects who did not attain a regular rate with the cube did not find the limited five-minute practice period on the Schröder staircase sufficient time in which to attain their best rate. The real value and significance of the preliminary practice on the cube was learned from these practice subjects. It was necessary for each subject to become thoroughly acquainted with the methods when practicing on the cube and to attain a regular rate which usually indicated a maximum or an approximation to it for the individual concerned. This does not mean that the subject, after having practiced on the cube, would be equally as facile from the start when given the Schröder staircase, but that he would have been so acquainted with the methods of shifting and know what was meant by his maximum rate, that a definite practice time on the staircase could be set for all the subjects. For example, some subjects when presented with the cube tried for five minutes without shifting once; others were able to do so immediately. For this reason a definite practice period for the staircase itself was difficult to determine, since for some it might mean merely getting started and for others time to gain facility. The
preliminary practice time on the cube was therefore given so that the subject could take as much time as necessary to acquaint himself with the procedure. Although some subjects had difficulty in beginning the shifts on the staircase, it was evident from the scores of the practice subjects that the maximum rate could be reached within the given five minutes, provided they had previously attained their rate on the cube.

After the subject had thoroughly practiced on the cube and attained a fairly regular rate he was given a one-minute rest period. Then the Schröder staircase was presented and he was asked to practice for five minutes and during this time to try to shift the figure as often as possible. After this practice period a one-half-minute rest period was given. The five one-minute trials were then begun with a half-minute rest period between trials. The shifts were recorded for each minute by marking the score sheet every time the subject said "now." After the five trials were given, the number of shifts for each minute, the average of the first three trials, and the average for all five trials were computed. The averages for the most part were within close range of each other.

In the following chapter the results of Experiments I and II will be given along with the correlations obtained. A few introspective reports gained from the subjects during the practice periods and after the trials were completed, will also be given.
CHAPTER IV

RESULTS AND CORRELATIONS

In the experiments on span of perception and voluntary shift of attention, both quantitative and qualitative results were obtained; the latter were for the most part volunteered reports, though a few questions concerning methods, experiences, etc., were asked of the subjects. The results will be first discussed separately for each test described in our procedure, and then the correlations between the two tests will be investigated.

Experiment 1

Before stating the results it might be well to offer a further brief explanation of the numerical value presented as the subject's span of perception. As was mentioned in the previous chapter, the method used for ascertaining the subjects' span was the Constant Stimuli Method. 1 Jevons in relating his experience with the visual perception of black beans in the white box concluded that his limit was between 4 and 5. Fernberger criticizes Jevons' report and mentions the greater accuracy of the Constant Stimuli Method.

1 See above Chapter III p. 45 ff.
Jevons' results, although they involve three inversions, can, nevertheless, . . . be treated by the method of constant stimuli. For his data the limen is 10.28 beans and the coefficient of precision is 0.143,—a statement that is much more definite than Jevons' conclusion; 'The limit of complete accuracy, if there were one, would be neither 4 nor 5, but halfway between them. . . .'²

Later in the same paper Fernberger says, "The statistical limen, that stimulus-value for which correct judgments are given in 50 per cent of the cases, is the most reliable measure of the range of visual apprehension."³ A further explanation of the meaning and accuracy of a limen so obtained is explained more fully by Fernberger in the same paper.

Limen is a statistical limen, a calculated quantity which summarizes observed results for purposes of scientific comparison. When one finds the upper threshold of tone to be say 18,264 vs., one does not seek to construct a stimulus for this frequency in order to see whether it will give 50 per cent positive judgments. One is satisfied with the computed limen as a part of a statistical account of observations already made.⁴

³Ibid., p. 133.
⁴Ibid., p. 123.
The spans of perception for the thirty-four subjects in our experiment included a comparatively wide scatter with the individual limens ranging from 5.7 to 10.8 for rings, and with the mean for the entire group at 8.05. This range and mean obtained from our thirty-four subjects is in close agreement with those obtained by other experimenters. Oberly, in his experiment on six subjects obtained a mean of 8.21 dots for method of apprehension.\(^5\) Glanville and Dallenbach give 8.8 dots for the average obtained from their subjects.\(^6\) Woodworth in a compilation of data obtained from experiments performed by Fernberger, Oberly, Glanville, and Dallenbach gives the mean for span of perception for number of dots at 8.36 and the variation of individual spans ranging from 6 to 11.\(^7\) Thus our results follow closely those of the above experimenters both in regard to range of individual spans and the mean obtained from the various groups. Figure 6 shows the graphical representation or distribution curve of spans for our subjects. Table II shows the span for each subject and the corresponding rates for voluntary shift of attention.

The limen for span of perception is not an invariable figure, and the threshold may increase to a certain extent

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\(^7\) Experimental Psychology, pp. 690-691.
Distribution of Span of Perception
For 34 Subjects

<table>
<thead>
<tr>
<th>Span</th>
<th>f</th>
</tr>
</thead>
<tbody>
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<tr>
<td>6.0</td>
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<tr>
<td>6.3</td>
<td>2</td>
</tr>
<tr>
<td>6.6</td>
<td>2</td>
</tr>
<tr>
<td>6.9</td>
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<td>15.8</td>
<td>18.0</td>
<td>17.5</td>
<td>18.0</td>
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<td>16.0</td>
<td>17.40</td>
</tr>
</tbody>
</table>
with practice. However, in a group such as ours, the spans obtained under like conditions indicate the relative position for each subject in the group. Though the span of perception is not invariable for each individual, tests under like circumstances administered at different times show this variability to be within a limited scope. Oberly in administering the same test three different times, though restrictions of method differed for each test, noticed the effects of practice. "All of the Os showed an increase in the size of the threshold as experimentation progressed." And further in the same experiment Oberly says, "... increase with regard to magnitude of the threshold values for all Os is to be found for progressive practice in apprehension." Woodworth also mentions this effect of practice from his study of several experiments on span.

Practice increases the average span. Some Os become expert in grouping, others in counting. If the same arrangement of dots recurs frequently in an experiment, O comes to recognize it and thus to know the number directly without subdivision into groups.

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9 Ibid.
10 Experimental Psychology, p. 693.
It should be clearly understood, however, that span of perception remains constant in the sense that, in spite of practice effects and the increase in the size of the threshold which may follow, an individual span remains close within its original bracket. In other words, a person whose span is narrow upon the first test, providing the conditions for testing are the same, will keep approximately the same span in the second test, though there may be some increase due to practice effects. These effects are never so great as to indicate that there is a change from a narrow to a broad span.

In order to check the validity and accuracy of the first of our tests given to obtain span of perception, a retest was given to eight of the subjects. In order to obtain a representative cross section of the whole group for the retests, subjects were selected from the middle, and two extreme ends of the original thirty-four scores. The following are the results for the retests.

**Table III**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Test I</th>
<th>Test II</th>
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<tbody>
<tr>
<td>Bk.</td>
<td>10.8</td>
<td>11.09</td>
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<tr>
<td>An.</td>
<td>9.4</td>
<td>9.09</td>
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<td>Ls.</td>
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<td>9.87</td>
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<td>Cr.</td>
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<td>Fr.</td>
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<td>8.9</td>
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<tr>
<td>Ad.</td>
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<td>8.4</td>
</tr>
<tr>
<td>Jn.</td>
<td>6.5</td>
<td>6.97</td>
</tr>
<tr>
<td>Sc.</td>
<td>5.7</td>
<td>6.60</td>
</tr>
</tbody>
</table>
These retests show what is meant by increase in threshold of span and at the same time the constancy of span of perception. For two of our subjects, Cr. and Ad., the span was exactly the same in two tests. One subject, An., showed a slight decrease and the others the usual increase in threshold. Yet this increase does not indicate a change from narrow to broad span; those whose spans were narrow in Test I were likewise narrow in Test II, those whose spans were close to the mean in Test I were likewise close to the mean in Test II, and the same is true for those having broad spans. This constancy is evident in Oberly's tests as well. Those subjects whose results indicated low spans in the tests for span of "attention" also had low spans in the tests for span of "cognition" and span of apprehension. A comparison between two of his subjects will make this fact clear:

<table>
<thead>
<tr>
<th></th>
<th>Mc.</th>
<th>Sc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td>3.5</td>
<td>5.1</td>
</tr>
<tr>
<td>Cognition</td>
<td>7.4</td>
<td>9.4</td>
</tr>
<tr>
<td>Apprehension</td>
<td>7.9</td>
<td>9.5</td>
</tr>
</tbody>
</table>

At the end of each test, the subject was asked to explain the methods used in perceiving the number of dots. All of the subjects reported the use of both counting and grouping. This was evident in many cases during the tests, for some of the

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11 For explanation of these terms see above Chapter III, p. 46.
subjects, immediately after the slide was exposed, began to point their finger towards the screen and count aloud as if the slide were still exposed. Others would count with both hands and one could observe that they were attempting to calculate the number in each group. The subjects whose spans were broad reported the smaller numbers immediately, but indicated that they grouped and counted those numbers, the judgments of which were not 100% correct. The subjects with narrow spans grouped and counted even 4 or 5 rings. Thus the ability to group a larger number within a unit is directly proportional to the width of span. The subjects with narrower spans saw even slides with 4 and 5 rings as two groups of rings. For example one subject with a very narrow span said aloud on the presentation of slide 5, "I know there were two in one group but I'm not sure whether the other group contained two or three." The experimenter asked some of the subjects in the wider-span bracket if they grouped four and five and they said definitely not but that they began to do so for 7 and 8. In our test, then, broad span indicated the ability to include a larger number of rings within one unit, since for the subjects with narrow spans three or four at the most seems to be the limit of rings they can perceive within a group, while those with broad spans could unify six or seven. This fact is also evident in the scores on the larger numbers. In Chapter III, Table I subject Bk. whose span on the retest was 11.09 had .25
per cent of judgments correct for slide number 13. Subject Ms. whose span was 6.5 reported "I do not know" for every exposure of slide 10 and obtained only .20 correct judgments for slide 9. We may conclude from this data that one's breadth of span is greatly dependent on the ability to synthesize greater amounts within a unit or whole.

Subject Bk., whose span was the broadest of our group, volunteered an interesting introspective report, the more significant because it was noticed by the subject rather than inferred by the experimenter. At the end of the test Bk. said; "This reminds me of the method our teacher insisted on in teaching us arithmetic. We were made to do the greater part of our problems mentally, even large and difficult ones and were not permitted to write or count aloud in making calculations. I learned to group many numbers together quickly. This test seems something like grouping numbers in arithmetic." Evidently this subject had gained facility in synthesizing large amounts of material especially of a numerical nature. Bk. was able to perceive the rings without error up to slide 8 inclusively.

In general, the subjects tended to underestimate the larger numbers and to overestimate the smaller ones. For example, slides 13 or 14 were usually reported to contain 10 or 11 rings while slides 8 and 9 were often reported to contain 12 or 13 rings. Another point observed was the noticeable
hesitancy to respond, on the part of the subjects, where there was question of numbers close to their limen. For example, a subject whose span was 8.0 would generally use more time subsequent to the exposures for slides 7, 8, and 9 than others either above or below. He might respond to 6 or 10 quite readily, even though the latter might be incorrectly judged, while those numbers close to his actual threshold often brought about some hesitancy.

Experiment II

In an experiment on duration of attention, Billings undertook to discover the rapidity of shifts on an ambiguous figure by having the subject press a telegraph key whenever his attention wandered from the first point of attention. In our experiment a simpler means of report was used and the word "now" was the indication given by the subject upon every shift. The results show that the simplest method of response possible is necessary, since oscillation rates of 95 per minute might be hampered by the necessity of pressing a key each time a shift was made. This type of response might serve as a distractor. Bills, after allowing a subject to learn how to control the shifts on an ambiguous figure, found that this subject in five minutes of steady voluntary effort obtained an average of 75

shifts per minute at first but, later, due to fatigue, decreased to 60 per minute.\textsuperscript{14} Woodworth mentions the variability of rates in different individuals. "The rate of oscillation varies, and in some counts averages 20-30 phases per minute."\textsuperscript{15} In our experiment the voluntary shifts were recorded for five one-minute trials. The following shows the highest and lowest individual scores from our group of thirty-four subjects.

\begin{table}
\centering
\begin{tabular}{|c|c|c|c|}
\hline
 & 1st minute & Average of 1st 3 minutes & Average of 5 one-minute trials \\
\hline
Highest & 93 & 95 & 96 \\
\hline
Lowest & 22 & 22 & 19 \\
\hline
\end{tabular}
\end{table}

The mean is approximately 50 for the average of the five trials.

Table II shows the complete list of scores and averages for all of the subjects. The range in fluctuation rates, like that of the subjects' spans, includes a comparatively wide scatter. Figure 7 shows graphically the distribution of scores for the first minute; Figure 8, for the average of the first three minutes; Figure 9, for the average of the five trials.

The methods used by the subjects to shift the figures varied from one to the other. Some directed their eyes back

\textsuperscript{15} Experimental Psychology, p. 697.
### Distribution of Rates of Fluctuation For 1 Minute

<table>
<thead>
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<th>Rate</th>
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<td>20 - 24</td>
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<tr>
<td>25 - 29</td>
<td>2</td>
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<tr>
<td>30 - 34</td>
<td>5</td>
</tr>
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<td>35 - 39</td>
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<td>95 - 99</td>
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\[ N = 34 \]
Distribution of Scores for the Average Rate of Fluctuations for the First 3 Minutes

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<td>25 - 29</td>
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<tr>
<td>30 - 34</td>
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<tr>
<td>40 - 44</td>
<td>6</td>
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<tr>
<td>45 - 49</td>
<td>5</td>
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<td>50 - 54</td>
<td>2</td>
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<td>55 - 59</td>
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<td>60 - 64</td>
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<td>70 - 74</td>
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N = 34

Figure 8
Distribution of Scores for the Average Rate of Fluctuations for the First 5 Minutes

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<tr>
<td>90 - 94</td>
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<td>95 - 99</td>
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</table>

N = 34
and forth to the part or section which they wished to have protrude, others mentioned that blinking the eyes helped to facilitate oscillations, though the latter was not regularly an efficacious means in bringing about the shifts. Most of the subjects after practice found that it was best to direct their attention back and forth between two different points which they had determined beforehand as the two best points for shifting the pattern of the figure rapidly.

During the practice period on the cube, the increase in regularity of the fluctuations was especially noticeable. The subjects at first were often able to move the figure back and forth for a few times. Then followed a long time when the figure seemed blocked. After considerable effort and practice these shifts assumed a regular rate. The subjects manifested the evident "pull" between the two positions and frequently made movements with their head as if they were attempting to aid the shifts by these movements. They remarked frequently about the difficulty they were encountering in trying to "push the figure up." In regard to both the Necker cube and the Schröder staircase, the subjects found the "upside down position" more difficult to obtain while the original position, i.e. the one which is noticed upon looking at the figure for the first time, was considered the position most easily obtained and most persistently seen. Some of the subjects reported shifts to several different positions and these subjects
were usually those whose fluctuation rates were high; those whose fluctuation rates were low hardly ever saw more than two positions in either of the figures.

The differences in rate between voluntary and involuntary shifts of attention was noticeable among the practice subjects. These subjects were first asked merely to look at the figures and report the changes; the subjects were told to do so until fatigued. Later they were asked to voluntarily shift the figure as fast as possible. In the first case the rate was not only much slower but also much less regular, while in the latter case the effect of voluntary effort increased the rate and also, after some practice, brought about an almost periodic regularity in the shifts.

The first reaction of the subjects to the figures was somewhat significant. Those whose rates of voluntary shift were very high were able to shift the figures immediately upon presentation or very soon after. Those whose rates were low found the figures difficult to shift in the very beginning, though with effort and practice they often obtained a fair rate. The middle group varied, some finding the first shifts comparatively easy, others, quite difficult. Interestingly enough, the twelve subjects with the broadest span of perception were among the group that was able to shift the ambiguous figures immediately upon presentation. The results were not so consistently the opposite in regard to all of those in the
lowest bracket of spans. In regard to the subjects with the highest spans, their facility in shifting the ambiguous figures was so immediately noticeable as to enable the experimenter sometimes to guess the approximate span by this initial facility before referring to the records. This in itself would seem to indicate a relationship between span of perception and voluntary shift of attention. However, these statements are made only on the basis of observations of our thirty-four subjects, and from such a limited number one would not attempt to generalize about these conditions.

The correlations between span of perception and rate of voluntary shift of attention show a high positive relationship. The Pearson Product-Moment Method was used and correlations were computed between span of perception and the rate of voluntary shift of attention for the first minute; between span and the average of shifts for the first three minutes; between span and the average of all five trials. All three correlations are in close agreement with one another. For span and rate of voluntary shift for the first one-minute trial the correlation is $+0.810, \pm 0.038$; for span and the average rate for the first three trials the correlation is $+0.780, \pm 0.042$; for span and the average rate of voluntary shifts for all five trials the correlation is $+0.798, \pm 0.041$. This fairly high positive correlation indicates that among our subjects those who have broad spans of perception tend to have a high rate of voluntary shift.
of attention; those with narrow spans of perception tend to have a low rate of voluntary shift of attention. These results would seem to follow in agreement with those obtained by Father King S.J., who found that, among his subjects, those who had a broad span tended to be low perseverates and those who had a narrow span tended to be high perseverates.\(^{16}\) Our results would follow consistently, for a high perseverate, whose tendency is to persist in a given activity, would find it more difficult to voluntarily shift attention rapidly than would the low perseverate, whose tendency it is to change quickly and easily from one activity to another. We may emphasize this agreement further by recalling the observation made on the twelve subjects having the broadest spans in our experiment.\(^{17}\) The latter were those who were most facile in voluntarily shifting positions or patterns immediately upon presentation of the figure. These twelve subjects, though not also the twelve highest in rate of voluntary shift, ranked high in this activity.


\(^{17}\)See above p. 69.
CHAPTER V
CONCLUSIONS

From the quantitative results obtained from the two tests of our experiment and the correlations of the same we may say that, in general, individuals who have a broad span of perception tend also to have a high rate of voluntary shift of attention. This denotes a new aspect of the relationship which has always been known to exist between attention and perception. In the first chapter we mentioned that span of perception depended greatly upon attention since objects will be perceived only if our cognitive processes are directed towards these objects. If the results of our experiment are valid, may we not also say that shift of voluntary attention depends to a certain extent upon one's span of perception? Any test on span of perception given to a group of subjects will reveal the great differences that exist from one person to another in the ability to perceive amounts of material. The person whose span is broad will be more likely to perceive a whole figure or pattern in a shorter time than the person whose span is narrow, because the subject with a broad span takes in more,

1See above Chapter I, p. 13.
perceives more in one glance. The person whose span is narrow might necessarily require two or more views in order to apprehend the amount perceived in one glance by the subject with broad span. In shifting ambiguous figures, then, it would follow that the subject with broad span, since he is able to synthesize greater amounts of material in one glance, would be able to apprehend the whole figure more quickly in its various positional relationships; hence, he would be able to shift his attention from one total figure to the other with greater facility. The subject with narrow span does not perceive as much in one glance and consequently he would require more time to apprehend the various patterns; in order to shift the figure he must first be able to synthesize all the parts into one pattern and then change to a new synthesis giving a new position. The test on ambiguous figures requires the voluntary shift of attention from one pattern to another and not merely from one isolated part of the figure to another. The subject with narrow span cannot shift as rapidly because he cannot synthesize as rapidly. He cannot synthesize as rapidly as the subject with broad span because he cannot synthesize the same amount into a whole or unit.

The results of Father King's experiment on span of perception and perseveration might serve as a further corroboration of our conclusion. We would expect that the subject

\[2\text{See above Chapter II, p. 36.}\]
with broad span would be able to shift from one activity to another more easily, since he perceives more in a shorter time. This is characteristic of the low perseverate who tends to have a broad span. The high perseverate finds difficulty in shifting from one activity to the other and since he tends to have a narrow span, it would seem to indicate that one of the reasons for this difficulty is his need for more time to apprehend a given amount of material. The wholes which he synthesizes are smaller and he must necessarily require more time to apprehend the entire given material. When we speak of shifting from one activity to another or from one pattern to another in this experimental work, it must be remembered that we are speaking chiefly about the objective or externally manifest aspects of these activities and not about the inner processes of thought. When we mention breadth of span as a causative factor in perseveration or shift of attention we are speaking of it as one of the contributing factors and not as an only cause.

In the case of ambiguous figures the attention can move back and forth the more rapidly within a limited time in accordance with the time required for the perception of each position. However, voluntary attention aids perception for it increases the speed of percept formation for everyone. A person who looks at an ambiguous figure passively will notice changes of position in the figure before him but by voluntary
effort he can increase the rapidity of these changes to quite an extent. The ability to voluntarily shift a figure rapidly varies from person to person. This variation in ability is possibly due partially to the diversity in perceptive ability from person to person. The fact that voluntary attention increases the speed in shifts of attention was brought out by the experiment on our practice subjects; all of the latter showed a definite and sometimes a very great increase in rate of oscillations when told to voluntarily shift the figures which they had been observing only passively.

However, span of perception is not the only factor in voluntary shift of attention. Other experiments have shown that fatigue, drugs, etc., may also affect either the voluntary or involuntary rate of fluctuations of an ambiguous figure. But we can say with a good deal of certainty that span of perception is a factor in the voluntary shift of attention on visual data, and a very influential one.

Between span of perception and voluntary attention, considered apart from shift of attention, there is an interdependence, a definite interrelationship. Span of attention for sensory data depends upon the breadth of span of perception. We must make this distinction, for the power of attention in general includes the direction of both rational and sense cognitive powers. By our rational cognition we may attend to abstract notions without any relevant immediate perception, and
we may attend to relationships or ideas during the same time in which our sensitive cognition is directed to objective experiences. The more an individual is able to synthesize into a unified whole the greater is the amount which he can attend to directly and simultaneously. In our tachistoscope test, the subject who perceived seven rings because he was able to unify them so that attention could focus on all at once, judged their numerical value correctly. The subject who, on the presentation of seven rings, judged there to be but five was unable to attend to all the rings since his span of perception was more limited. If the latter subject overestimated the seven rings and said there were ten instead of seven, he still revealed his inability to attend to seven rings; for by attempting to do so confusion resulted instead of a true judgment.

This relationship is denoted too in rate of shift; a person whose span of perception includes more material in one glance can unify it more quickly than a person who must use two glances to perceive the same amount. As we have seen, voluntary shift from one pattern to another depends on the speed at which these patterns are obtained. We may say that in this sense voluntary shift of attention depends in some way upon the breadth of span.

Voluntary shift of attention is likewise dependent on breadth of span in the case of reading. The reader shifts his attention from one part of the line to the other according
to the amounts he perceives in one fixation. If one individual requires two fixations to perceive a phrase because his span is small, his rate of shift in attention from one phrase to another per minute will be slower than the individual who perceives the whole phrase in one fixation. The slow reader must keep his attention on the words longer in order to synthesize them into a phrase. Reading, however, is closely allied to abstraction since it requires meaningful interpretation. Hence, intellectual capacity is also a factor in the voluntary shift of attention from one phrase to the other; for shift of attention would be delayed by lack of comprehension. This is one proof that sensory perception is not the same as comprehension or awareness of meaning. On the other hand, there is a close connection between span of perception in reading and ability to understand what was read. It is the consensus of opinion among teachers that pupils who read more rapidly likewise understand better the material read.

The rapid reader generally understands well because he sees the reading matter in large units, which—in turn—make comprehension unusually high. Speed and comprehension are therefore directly related because both depend upon the use of a wide reading span. 3

Another author came to the same conclusion after numerous in-

3Iuella Cole, The Improvement of Reading, p. 199.
vestigations relating to reading. "There is positive correla-
tion between speed and comprehension when children read care-
fully. As in the case of adults, there are numerous exceptions
to the general rule." In a chapter entitled, "The Psychology
of Reading," Paul Klapper states a similar conclusion.

Researches in the field have
established the conclusion that,
all things considered, rapid
readers are the intelligent
readers, that is, they obtain
more of the thought, form more
vivid images and retain the con-
tent of the text better. It
is not rare to find an intelli-
gent reader who is slow, but
results of careful tests show
clearly that rapid reading and
effective reading are usually
related as are slow reading
and ineffective reading.

Other authorities such as O'Brien, Huey, Quantz, Dearborn, and
others have found the same results from their investigations.
A better example of the relationship between span of percep-
tion and voluntary shift of attention is the ability to appre-
hend a group of nonsense words or syllables. If a group of
subjects were presented with a page of nonsense words, the one
with broad span would shift his attention more rapidly because
he could group more within one glance than the subject with
narrow span. Since he would require fewer fixations, his

4William S. Gray, Summary of Investigations Relating to Read-
ing, p. 131.
5Teaching Children to Read, p. 20.
shifts of attention would reach a higher rate within a given time than would those of the subject with a narrow span.

We might reverse the problem by stating that breadth of span is dependent upon an individual's habitual use of his power of attention, since in order to perceive anything one must first attend. In this sense span does depend on attention because the tachistoscopic presentation is not perceived unless the subject attends carefully. If he attends only partially, he perceives incorrectly or incompletely. But the rate of shift in voluntary attention must, in turn, depend on the amount perceived; for one cannot shift to a second pattern until the first is completed. Here again, the time required for integration of material would depend upon the ability to unify greater amounts into a whole.

Though attention is not will it is an energy directed to an object by the will. From the foregoing arguments it may seem that the will is in every way dependent upon perception since we have stated that the rate of voluntary shift does depend upon breadth of span. Such is not the case; a person may in a very real way attempt to direct mental energy toward one object or another or toward one pattern and then another without necessarily accomplishing the desired effect. How often we endeavor to attend to a particular topic and fail. One may will, i.e., elicit a will act intended to result in a shift of attention, but he unable to do so. This failure does
not necessarily affect or change the will itself but only the execution of an act of some other power commanded by the will. The volition to do so may remain whether the object is successfully attended to or not. Perception aids in the performance of the voluntary act, not in the volition itself. We are not stating here that the power of the will is dependent upon perception directly, but merely that the voluntary rate of shift of attention from one pattern of sensory data to another depends on the time required to form some pattern or whole of perception. In this type of voluntary movement perception influences the rate.

There are many other factors which could profitably be studied in regard to both attention and perception. One conclusion which we may draw, in general, from the quantitative results and correlations of our experiment on span of perception and voluntary shift of attention is: breadth of span is a factor related to voluntary shift of attention. It is a factor upon which, in this respect, the rate of voluntary shift seems to depend.
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BOOKS


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The thesis submitted by Sister Marian Dolores Robinson, S.H.N. has been read and approved by three members of the Department of Psychology.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content, form and mechanical accuracy.

The thesis is therefore accepted in partial fulfillment of the requirements for the Degree of Master of Arts.

Nov. 23, 1944
Date

Signature of Advisor