EFFECT OF DISTRIBUTION OF INSPECTION TRIALS ON THE MAGNITUDE AND RETENTION OF THE KINESTHETIC AFTER-EFFECT

Thesis for the Degree of M. A.

MICHIGAN STATE UNIVERSITY

Duane L. Varble

1961

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By

Duane L. Varble

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

Department of Psychology

1961

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ABSTRACT

EFFECT OF DISTRIBUTION OF INSPECTION TRIALS ON THE MAGNITUDE AND RETENTION OF THE KINESTHETIC AFTER-EFFECT

by Duane L. Varble

This experiment was an attempt to formulate and test certain expectations which were derived from two contrasting positions: (1) that KAE is a learning type phenomenon and that satiation is a neural change similar to a memory trace, and (2) that KAE is produced by a process similar to or synonymous with reactive inhibition.

The derived expectations were based on the assumptions that massed versus spaced inspection trials would lead to different results in the size of KAE. It was further assumed that the retention of KAE would be affected in different ways by the distribution of inspection trials.

To test the derived expectations, the following experiment was designed. Six groups each consisting of 19 subjects were individually tested for KAE. Each subject made judgments of the equality of widths of two blocks of wood. These judgments were made in series of four immediately before the inspection period (pre-test), immediately after the inspection period (post-test), and after a specified amount of time had elapsed since inspection (retest).

All subjects received 16 thirty-second inspection trials. For half the subjects these trials were massed, and for the other half the trials were spaced. Then one of the massed inspection groups and one of the spaced groups each returned for retesting after intervals of either 15 minutes, 24 hours or 7 days.

The difference scores between the pre-test and post-test PSE's were the immediate KAE's. The difference scores between the pre-test and the retest PSE's as well as the difference between the post-test and retest PSE's were used as measures of retention after-effects.

A t-test and two analysis of variance designs using these difference scores attempted to test the above mentioned expectations. None of these tests were statistically significant, and thus, the basic question as to whether KAE's are produced by a learning type phenomenon (memory traces) or by reactive inhibition could not conclusively be answered, but the evidence was in favor of the learning type explanation. The following results were obtained:

1. Distributing the inspection trials had no significant effect on the size or persistence of KAE's.

2. A total of eight minutes of inspection established relatively large KAE's which did not decrease in size after an interval of a week. This is in contrast to the persistence of most visual after-effects. Also, there is an indication that KAE's are a

specific experience which is not affected by ordinary day to day use of the hands.

3. A correlation of .51 was obtained between the immediate after-effects and the retention after-effects. Stability co-efficients for this relationship indicated that KAE's are most stable after 15 minutes but could be reliably obtained after intervals of 24 hours or 7 days.

4. Negative correlation coefficients of -.47 and -.51 were obtained between the size of the pre-inspection PSE and the size of the immediate KAE and the retention KAE respectively. This meant that subjects with large pre-inspection PSE's tended to have small after-effects.

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Acknowledgments

I would like to thank the members of my committee, Dr. Donald M. Johnson and Dr. Gerald King, for their help with this thesis. I would especially like to express my gratitude to my committee chairman, Dr. Paul Bakan, for his patience and understanding as well as his invaluable help with the thesis proper.

I would also like to acknowledge the aid with the statistical computation rendered by Gilbert Rothman.

Finally, I would like to express my deepest gratitude to my wife, Charle. I am grateful for her understanding and support when such were needed. Also, I am indebted to her for the many clerical tasks she willingly performed and which went a long way in making the completion of this thesis possible. To her this thesis is dedicated.

Duane L. Varble

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Introduction

An after-effect is the distortion or displacement of a perception which occurs after exposure to an inspection stimulus. It is usually manifested by a difference between perception of a standard stimulus before and after exposure to an inspection stimulus. After-effects are not restricted to any particular sense modality.

Visual after-effects were the first to be studied, and much of the work on after-effects has been concerned with the visual effects. Gibson (1933) discovered the first visual figural after-effect in 1933. This was caused by the wearing of prisms over the eyes. The after-effect occurred in the form of displacement of vertical lines when he removed the prisms. He called this phenomenon "adaptation after-effect" and conducted formal experiments to prove that after-effects could be produced without the use of prisms.

Gibson and Radner (1937) later studied after-effects in both the visual and kinesthetic modalities. Köhler and Wallach (1944) found after-effects in patterned vision and postulated a theory of neural satiation to explain after-effects in general. Kohler and Emery (1947) found visual after-effects in the third dimension. Auditory after-effects have been obtained by several investigators. Deutsch (1951) studied AE using pitch. Jones and Bressler (1949) studied the displacement after-effect in auditory localization and Krauskopf (1954) found after-effects in auditory space.

After-effects have consistently been obtained in the kinesthetic modality. Since the present experiment was concerned with kinesthetic after-effects (KAE), the research in this area will be reviewed more extensively.

The classical study of KAE was done by Köhler and Dinnerstein (1947) and published in 1947. They found that Gibson's "adaptation after-effect" or "after-curvature" could reliably be obtained in kinesthesis but could not be easily measured. After some exploration, Köhler and Dinnerstein found that after-effects could be obtained by using judgments of width. They had blindfolded subjects judge the width of a standard sized block held in one hand by using the other hand to find a point of equal width on a second variable sized block. The subjects then "inspected" a third block, either wider or narrower than the standard block. The inspection consisted of rubbing the inspection block with the hand that held the standard block before inspection. Then, when the subjects made judgments of the equality of the widths, as they had done before inspection, there was a definite tendency for those subjects who had rubbed the narrow inspection block to subsequently make their judgments of equality wider than they had before inspection. The reverse was true for those subjects who had rubbed the wider inspection block. Köhler and Dinnerstein called this distortion "kinesthetic after-effect" (KAE). It was measured by calculating the difference between the average pre-inspection and post-inspection judgments. They found large individual differences but consistent after-effects among many individuals. Köhler and Dinnerstein used this technique to study the effects of many of the variables involved in kinesthetic after-effects. After several experiments, they concluded that the important criteria for obtaining an after-effect was that the fingers have tension in them and that they be held in the same or similar position during the inspection period.

Other investigators have used Köhler and Dinnerstein's apparatus and testing procedure to investigate the variables involved in kinesthetic after-effects. Charles and Duncan (1959) studied the distance gradient in kinesthetic after-effect and found a significant distance gradient of inverted-U shape, i.e., the amount of after-effect first increased, then decreased as the difference between the standard and inspection stimulus increased.

Wertheimer (1954) studied constant errors in the measurement of figural after-effects. He concluded that the preferred hand should always be used to find the PSE on the variable stimulus because this hand has the smallest Bilateral Kinesthetic Difference (BKD). BKD is defined operationally by Wertheimer as the difference between the pre-inspection and post-inspection PSE's.

Wertheimer and Leventhal (1958) investigated the effects of varying amounts of satiation (length of inspection periods) on the size of the after-effects. The results showed that the size of the after-effect was positively correlated with the amount of satiation given. Recently, Heinemann (1961) has published a study in which he used standard blocks of various widths and tested daily for 11 days. He found the expected relationship that after inspection, the subjects overestimated the width of the standard blocks that were wider than the inspection block and underestimated the width of the standard blocks that were narrower than the inspection block. No after-effects occurred when the inspection block and the standard blocks were objectively equal.

The present paper was primarily concerned with two variables:

1. The spacing of inspection trials.

2. The time interval between the inspection trials and the retention tests.

To study these effects all the inspection trials were given in the initial session.

There is very little literature on the effects of massed vs. spaced inspection trials on after-effects. Bakan[1] has done some unpublished studies with the spacing variable. He found no significant difference in size of after-effects between massed vs. spaced conditions.

The only other experiment on this variable was an unpublished doctoral dissertation by Mountjoy (1957). He studied the effects of exposure time and intertrial interval upon rates of decrement

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[1]Personal communication

in the Müller-Lyer Illusion. Because only an abstract of this work is available, the details of the experiment cannot be reported. Mountjoy found no significant effects of either the intertrial interval or intertrial task variable on the rate of decrement of the M-L Illusion.

There has been more work on the permanence of after-effects. Gibson (1933) reported earlier that his type of visual after-effects tended to persist over a few hours or even days. With regard to kinesthesis, Köhler and Dinnerstein (1947) found that by testing daily over a period of weeks, the pre-inspection judgments (PSE) and post-inspection judgments (PSE) grew in size. At the same time, the difference between these two (the after-effect) grew as well. When this data was averaged and plotted over a period of several days, the resulting graphs appeared very similar to the familiar learning curves obtained on such tasks as the pursuit rotor. The fact that the pre-inspection judgments and the after-effects grew suggests that the inspection produced somewhat permanent satiation. This indication of permanence was further supported when Köhler and Dinnerstein retested two subjects without giving them inspection. These subjects showed significant after-effects 3½ and 5 months after the last inspection period.

Later, Wertheimer and Leventhal (1958) reported an experiment on the permanence of satiation or after-effects. They gave several subjects 2 minutes of inspection daily for several days, then tested for after-effects bi-monthly. They found after-effects significant at the .05 level of significance as much as 6 months later. For two subjects there were significant after-effects 8 months after the last satiation period.

Thus, the effect of distributing the inspection trials has largely been neglected, and while the persistence of AE has been studied to some extent, such experiments always included several inspection sessions. This study hoped to investigate these variables simultaneously. To explain the design of the present experiment, the theoretical aspects of the problem must be considered.

The major theory which may be regarded as an explanation of figural after-effects (FAE) is Köhler's (1944) theory of neural satiation. This theory is presented in detail in the Köhler and Wallach article (1944). The theory of neural satiation uses the Gestalt concept of psychophysical isomorphism, i.e., the idea that perceptual experience is isomorphic with electrochemical patterns in the cortex or the brain field. The basic postulate is that "inspection" causes a change in the neural tissue. This change occurring in the brain field is called "satiation" and results in a subsequent alteration of the percept. The change from the pre-inspection percept to the post-inspection percept is called the after-effect and is a resultant of a change in brain tissue (satiation) induced by the inspection stimulus.

There are other theories for explaining figural after-effect (FAE) such as Osgood and Heyer's "statistical hypothesis" (1952). However, these theories have been much less influential than the satiation theory.

An issue in the recent literature on FAE has been concerned with the similarities between "neural satiation" and other concepts. Two concepts in particular have been compared with "neural satiation." Duncan (1956), Eysenck (1955) and others have pointed out the similarity between satiation and reactive inhibition. On the other hand, Köhler and Fishback (1950) have suggested that neural satiation may be a change similar to that underlying memory traces.

Reactive inhibition (I_R) is Hull's (1943) concept. He has explained the concept as follows:

> All responses leave behind in the physical structures involved in the evocation, a state or substance which acts directly to inhibit the evocation of the activity in question. The hypothetical inhibitory condition or substance is observable only through its effect upon positive reaction potentials. This negative action is called <u>reactive inhibition</u>. An increment of reactive inhibition is assumed to be generated by every repetition of a response whether reinforced or not, and these increments are assumed to accumulate except as they spontaneously disintegrate with the passage of time. (Hull, 1943)

Duncan (1956) was among the first to point out the similarities between satiation and I_R. While Hull was satisfied with a peripheral interpretation of reactive inhibition, Duncan interpreted the concept in the modern sense as a generalized centrally located phenomena. Duncan reviewed the studies in the literature which demonstrated the similarities between satiation and I_R. The two major similarities were in terms of the central locus and similar effects of both I_R and satiation. These similarities are best exhibited in the following quotes from Duncan:

> Köhler and Wallach, and Gibson, have shown that satiation has a central locus by demonstrating that figural after-effects occur when the inspection is presented to one eye and the test-figure to the other eye...Ammons, Grice and Reynolds, Irion, and Gustafson, Kimble and Rockway, have shown that it (I_R) is not confined to effectors involved in the response. Therefore, it may be assumed that I_R also has a central locus. (Duncan, 1956, p. 229)

Duncan then goes on to show how I_R and satiation have the same effects.

> Both processes have essentially the effect of distorting behavior away from some criterion or standard. This is obvious for satiation; the process is inferred from distortions in the perception of figures. In the case of IR the effect occurs while stimulation is still continuing, e.g., during highly massed practice on a motor task, as measured by a depression of performance as compared either to an initial performance level or to performance of S's working under distributed practice...(Duncan, 1956, p. 230)

Duncan suggested that satiation and I_R may be two names for the same basic process.

Eysenck (1955) has also studied the relationship between the production of after-effects and I_R. He measured I_R in terms of reminiscence scores and the size of KAE. He was led to conclude that:

> Phenomena of reminiscence, of massed and spaced learning, of vigilance, of blocking, and many others have been interpreted in terms of inhibition. While it remains possible, of course, that in each separate case we must

> have recourse to a different type of inhibition, this does not seem a likely contingency and the hypothesis certainly seems worth testing that it is the same type of cortical inhibition which causes all these phenomena, as well as the perceptual ones discussed above (KAE's). (Eysenck, 1955, p. 103)

Rechtschaffen (1958) tested Eysenck's hypothesis using visual after-effects and found no significant correlation between I_R or VAE. However, he hesitated to conclude that they are different processes. Rechtschaffen also reports an unpublished study by Meier (1956) who found a significant negative correlation between the amount of reminiscence on inverted alphabet printing and the amount of KAE.

In spite of the few indications to the contrary, the similarity between satiation and I_R appears to be a strong one. If they are the same process, both the size and the retention of KAE should be affected by the distribution of inspection trials. Thus, using the logic of Duncan (1956) and Eysenck (1955), reactive inhibition would temporarily impede learning in the form of acquisition of skills but should facilitate the acquisition of after-effect. This follows logically if reactive inhibition, which inhibits learning, and neural satiation, which leads to after-effect, are two names for the same basic process.

In contrast to Duncan's and Eysenck's positions is the interpretation of neural satiation suggested by Köhler and Fishback (1950). Kohler and Fishback used the concept of satiation to explain how they experimentally "destroyed" the Muller-Lyer Illusion. Köhler and Fishback felt learning or "practice effect" did not adequately account for the destruction of the illusion. They further postulated that neural satiation, which presumably did destroy the illusion, was quite similar to memory traces. Of course, memory traces are involved in learning. The reasons for this interpretation are best illustrated by quotes from Köhler and Fishback's article:

> Actually, the effect of many experiments in an immediate sequence is so strong that, when the illusion has been destroyed, it may be brought back to life again merely by giving a long series of further experiments... Obviously, such observations resemble well-known facts in the field of learning, namely the inhibitions which make it difficult to memorize monotonous series of items, or to establish a precise motor performance in often repeated trials. (Köhler and Fishback, 1950, p. 339)

The ties between learning phenomena and satiation are further strengthened in the following quote:

> ...not only the obstacle which delays destruction of the M-L Illusion but also the inhibitions which accompany some forms of learning are therefore to a degree reversible. Reminiscence as a certain improvement of recall when tests are not given immediately is, of course, merely a special form of the same fact. (Köhler and Fishback, 1950, p. 400)

Köhler and Fishback, thus, equate the inhibitions observed in repetitive learning tasks with the obstacle to satiation therefore to the development of after-effects. For them this obstacle is satiation in the "wrong" places:

> It follows that during a long rest period satiation in the 'wrong' places can gradually decrease, and that therefore the obstacle can largely disappear, while satiation in the 'right' places remains very strong. (Köhler and Fishback, 1950, p. 402)

The decrease of satiation in the "wrong places" after a rest period is equivalent to the decrease of inhibition in learning tasks which, in turn, is responsible for reminiscence.

Once the similarity between the obstacles involved in learning experiments and in after-effect experiments was established, Kohler and Fishback speculated about the similarity between memory traces and satiation patterns:

> We must therefore now ask ourselves how satiation is related to memory...Little is known about memory traces. They are defined by certain operations, such as recognition, recall, and so forth, which they are supposed to explain. But if they are to serve this function, we must ascribe to them at least one fundamental characteristic: to a considerable degree, memory traces must resemble the processes by which they are established. It is true that sometimes we have reasons to suspect that the traces are defective; but this very expression points to the fact that in many instances the correspondence must be fairly good. As a consequence, the theoretical situation in this field is now as follows. It is assumed that the brain processes which go with psychological events establish memory traces, and that these processes resemble the processes in question. But at the same time these processes form satiation patterns which must also be adequate representations of the processes. It seems hardly natural to believe that a given process establishes simultaneously two altogether different effects in the nervous system which are both virtually pictures of that process. Thus, the question arises whether the two effects, memory traces and satiation patterns, can perhaps be identified. But memory traces are only most indirectly defined, while patterns of satiation have now been given an interpretation in fairly specific biophysical terms. Under these circumstances, the two concepts can be profitably identified only if the concept which is less well understood is reduced to the one which is much better defined. Hence, our question must actually be whether satiation patterns can be assumed to play the part which is commonly attributed to memory traces. (Köhler and Fishback, 1950, p. 405).

After commenting on the persistence of after-effects both in their own studies and others, Köhler and Fishback state: "...According to this evidence, satiation patterns may be persistent to a degree which makes them comparable to memory traces in this respect also." (Köhler and Fishback, 1950, p. 407).

Finally, after presenting several arguments and demonstrations to show why satiation patterns and memory traces could be the same phenomena, Köhler and Fishback conclude: "...It seems possible that memory traces are weak patterns of satiation; but at the present time no convincing proof of this thesis can be given." (Köhler and Fishback, 1950, p. 409).

Thus, for Köhler and Fishback neural satiation and memory traces are essentially equivalent. For them, reactive inhibition would impede learning or performance in massed practice. At the same time, satiation in the "wrong" places, which is their equivalent of I_R, would impede the establishment of figural after-effects under some circumstances.

Therefore, the view that neural satiation and reactive inhibition are the same process would lead to one set of expectations for figural after-effect. The view that satiation and memory traces are the same would lead to another set of expectations. Such expectations would stem not only from the nature of the views in themselves, but also from what has been observed in learning experiments in the past.

As previously mentioned, the decrements in performance during massed practice and reminiscence after a rest period are commonly attributed to the effects of reactive inhibition. Also well known is the fact that spaced practice is more effective in terms of learning than massed practice. Kimble (1961) cites many examples of this effect.

Less well known is the relationship between the distribution of practice and the retention of the material learned. This is exemplified by a quote from McGeoch and Irion's The Psychology of Human Learning (1952). They state:

> A number of studies have been concerned with a comparison of the degrees of retention of materials learned under massed and distributed practice. In general, material learned by distributed practice tends to be retained better than material learned by massed practice, although for short retention intervals and for certain types of learning tasks, exceptions must be made to this general conclusion. (McGeogh and Irion, 1952, p. 150).

The present study was designed around known relationships in the field of learning. The study tested for similar relationships in the area of kinesthetic after-effect (KAE). Specifically, the study is concerned with the effects of distribution of inspection trials on the size and retention of kinesthetic after-effects.

With the assumption that neural satiation is directly or indirectly the cause of figural after-effects, the view equating satiation with I_R would lead to expectations contrary to the view which equates satiation and memory traces. The expected effects of massed vs. spaced inspection trials should be opposed for these opposing views.

Specifically, the question becomes: Is the KAE produced by a learning type phenomena analogous to memory traces or is the KAE brought about by reactive inhibition? To answer this question six independent groups of subjects were given an equal number of inspection trials, tested for immediate KAE, and tested for retention KAE after varying intervals of time. Three of these groups received massed inspection trials, and three received spaced inspection trials. Then, one of the massed condition groups and one of the spaced condition groups were each tested either 15-minute, 24-hour or 7-days after the inspection period.

This experimental design was an attempt to explore the following possibilities:

1. If KAE's are caused by a reactive inhibition type phenomena, those groups receiving massed inspection trials should have larger immediate after-effects than the spaced inspection groups. Of course, this assumes I_R increases during performance (or inspection) and dissipates during rest as Hull and others postulate.

2. On the other hand, if KAE's are produced by a learning type phenomena (memory traces), then the groups receiving spaced inspection trials should have the larger after-effects.

3. For retention after-effects, the massed groups may have larger after-effects than the spaced group at the 15 minute retest if I_R is the cause. But if reactive inhibition is all that is involved, the after-effects should decrease in size after 24 hours

and be smaller yet after 7 days. Presumably, if a generalized type of I_R causes KAE, a 15 minute rest period may not be long enough for the KAE's to diminish substantially when 8 minutes of massed satiation or inspection is used.

4. Also we would expect the retention after-effects for both inspection conditions to decrease significantly in size after 24 hours and 7 days, if they are produced by memory trace processes. However, we would expect the after-effects of the spaced inspection groups to be larger than the massed inspection groups at all three retests (15 minutes, 24 hours, 7 days) if a learning phenomenon is involved.

Method

Subjects. - The subjects used in this study were students of both sexes enrolled in the introductory psychology course at Michigan State University for the spring term 1961. Each participating subject was given 1 hour research credit as partial fulfillment of a requirement of the psychology course.

The subjects varied in age from 17 to 26 years of age. Because of some indication in earlier studies that females had smaller after-effects than males, an attempt was made to balance the number of subjects of each sex in each group. As it turned out, due to unforeseen circumstances, 2 groups contained 7 females and 12 males each, 3 groups contained 6 females and 13 males each, and 1 group contained 5 females and 14 males.

Design of Experiment. - A total of 114 S's was divided into 6 groups, each containing 19 subjects. The assignment of S's to groups was more or less random, though some limitations on randomness were imposed by E's availability for testing only on Monday, Thursday and Friday. Thus, a subject in the groups to be retested 24 hours after the initial test had to be tested initially on a Thursday.

Two measures of kinesthetic after-effect (KAE) were taken on each S, a post-inspection measure and a retention measure. The time between these two measures was either 15 minutes, 24 hours, or 7 days. All S's were exposed to an inspection stimulus for a total of 8 minutes, but for half of the S's the exposure was massed (30 second inspection - 2 second rest...). For the other half, the exposure was spaced (30 second inspection - 30 second rest...). The combination of retention and spacing conditions makes for the 3 X 2 factorial design summarized in Table I which follows.

TABLE I

Design of Experiment

Inspection Conditions	Time between the post-inspection and the retention measures.		
	15 minutes	24 hours	7 days
Massed	S 1 2 3 . . 19	S 1 2 3 . . 19	S 1 2 3 . . 19
Spaced	S 1 2 3 . . 19	S 1 2 3 . . 19	S 1 2 3 . . 19

Apparatus. - The apparatus used in this experiment was developed by Bakan. It was similar in principle to the apparatus used by Köhler and Dinnerstein (1947), but it differed from their apparatus mainly in the method of varying the width of the test stimulus.

The apparatus consisted of three main parts: a standard stimulus in the form of a constant width block, a test stimulus in the form of a variable width block, and an inspection stimulus of fixed width.

The standard stimulus was formed by two pieces of beaver board 1/4 inch thick, 4 inches high and 5 inches long. These two pieces of beaver board were firmly anchored to a base in the vertical position with 1½ inches between the outer edge of one piece of board to the outer edge of the second piece of board. Thus, when the subject placed his thumb and forefinger on these outer surfaces, the standard felt like a solid block 1½ inches in width.

The test stimulus consisted of similar parts except that only one of the pieces of beaver board was solidly anchored to the base in the vertical position. The second piece of beaver board was also in the vertical position but was attached at a right angle to a third piece of beaver board approximately 1/3 inch thick, 3 inches wide, and 6 inches long. This piece lay flat on the base in the horizontal position. These two attached pieces of beaver board were not anchored to the base but slid freely within grooves so that the test stimulus formed by the vertically anchored piece of wood and the vertical sliding piece of wood could vary in width. Variations in width were made by moving the sliding piece of wood closer or further away from the stationary board as desired. To facilitate this movement, an adjustable metal bracket was attached to the outside edge of the sliding vertical part of the test stimulus and the outside edge of the standard block. These brackets served as a finger grip by holding the fingers in place. The blindfolded subject placed his forefinger in these finger grips with his thumbs on the opposite side of the block to make a "judgment" of the subjective equality of width of the two blocks. This was done by moving the sliding part of the test stimulus in or out until that block felt equal in width to the standard block. The point of subjective equality (PSE) was measured by a 6 inch metal ruler glued to the base of the apparatus with zero starting at the outside edge of the anchored piece of wood with the rest of the ruler extending along the sliding grooves. This ruler was calibrated in units of 1/32 of an inch so that the point of subject equality (PSE) could be measured to the nearest 1/32nd inch.

Both the standard block and test block were mounted 18" apart on a beaver board base, 1/4 inch thick, 10 inches wide and 24 inches long. (See Figure 1.) The inspection stimulus consisted of a board of smooth pine ½ inch thick, 2 inches wide, and 6 feet long. This was mounted on a table on the side of the S's non-preferred hand.

<u>Procedure</u>. - Each subject was tested individually and did not see the apparatus before or during testing. Upon arrival, the subject was given a "pre-test orientation sheet" to read. The orientation sheet read as follows: (after Figure 1.)

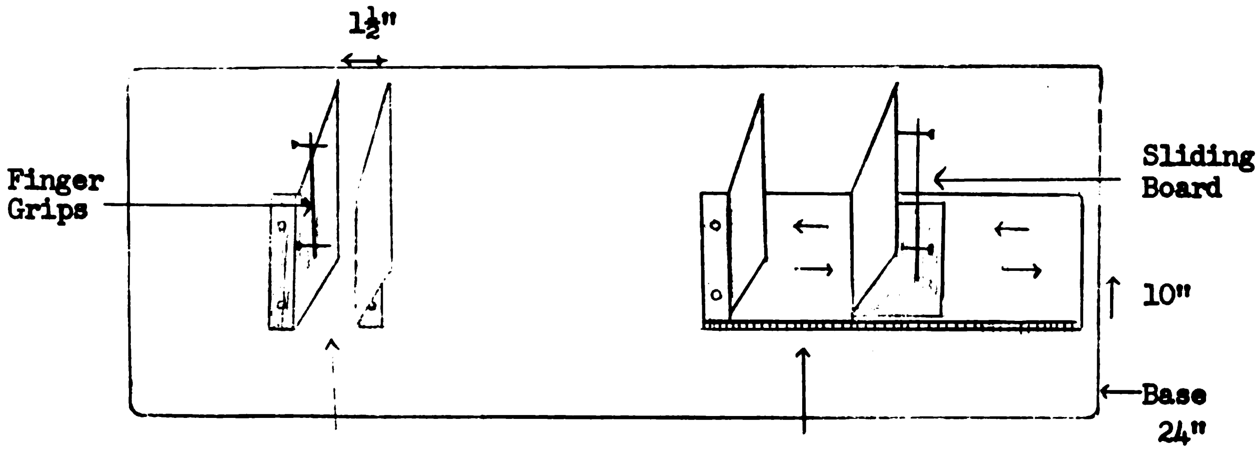

Figure 1. Test Apparatus

Width Test Pre-test Orientation

In this experiment you will be asked to judge the equality of widths or thicknesses of two wooden objects. One of these objects is called the constant width object, and you will feel its width by holding it between the thumb and forefinger of your non-preferred hand. (Left hand if you are right handed and vice versa.)

The other wooden object is called the variable width object and will be held between the thumb and forefinger of your preferred hand. The forefingers of both hands will be in finger grips, and you will adjust the width or thickness of the variable width object to equal the width or thickness of the constant width object. This will be done by moving the forefinger of your preferred hand in or out until the two objects feel equal in width. Further explanation and instructions will be given inside by the experimenter.

The apparatus was set up so that the preferred hand was used to manipulate the test block in making judgments. After a brief period, the experimenter obtained information on age, sex, preferred hand, class instructor, and previous participation in similar experiments. (Two other experiments involving kinesthetic after-effects were in progress at the same time, but no subject who had participated in an experiment similar to the present experiment was included in the sample.)

Then, the subject was blindfolded and led into a room where the apparatus was set up on two long narrow tables. On one of these tables was the apparatus with the standard stimulus and the test stimulus. The inspection block was placed on the other table. The subject stood between these tables facing the experimenter. With the subject in this position, the experimenter read the first paragraph of the general instructions. The rest of the general instructions were not read, but they were followed carefully by the experimenter, in order to make certain that everything was covered and that each subject got the same instructions.

Instructions for Width Judgment Experiment

"This is an experiment in the judgment of widths. We are interested in your perception of the equality of widths of two objects you are about to hold. It is important that your judgments be based on the feeling of the width of the objects between your fingers. That is why you are blindfolded. If you can see through or under your mask, please tell me now so that I may adjust it for you. Now, I will show you what to do."

"This is the constant width. I'll adjust the finger grips to fit the size of your fingers. We like them to be firm but not tight." (Adjust and check with S's. The first joint of both the thumb and the forefinger should come to the top of the piece of wood in the block.) "Try to put your fingers in exactly this same way each time."

"This is the variable width." (Demonstrate how it slides in and out with the S's hand in the finger grips.)

"I want the finger grips to feel the same for both hands. Now your task in this experiment is to adjust the variable width so that it feels equal to the constant width. We've found the best way to make judgments is to go past the equal point and come back to it. You may go either way. Also, press your fingers lightly against the sides of the objects when making your final judgments. We ask you to do this because people have a tendency to relax their thumbs and fingers, and then the judgments they think they are making are not the ones that show up on the apparatus. Now lift your hands off the apparatus please." (Set variable width at the starting point. After starting with the first practice judgment and ending with the last retest judgment, place the variable width block at 2 inches (descending), then 1 inch (ascending), another time at 1 inch, then 2 inches so that each series of four judgments goes 2, 1, 1, 2 or (DAAD). "Okay, start here. Tell me when you have finished a judgment." (Put S's hands back in the finger grips after each judgment. After the S makes 4 practice judgments, record the next 4 for the record. Time all judgments for the record.)

"Now, I'm going to have you rub a block of wood between the thumb and forefinger of your (non-dominant) hand. I'll show you where to rub and how fast to rub. Also, I'll tell you when to start and stop rubbing. After you are through rubbing, you will again make judgments of the width of a block of wood as you have been doing. This rubbing will take only a few minutes, but it may seem like a long time. Okay, do it like this." (Show how it is done using long sweeping strokes at approximately 50 traverses per 30 seconds trial.) "Begin."

(After rubbing is completed:) "Now I would like you to adjust the variable width so that it feels equal in width to the one in your (non-dominant) hand, right now. Do it as quickly as possible. Most people make the judgment in less than 15 seconds. Begin." (Record the first four judgments, then lead the subject back behind the screen and remove the blindfold.)

Up to the point where the subject rubbed the inspection stimulus, all subjects were treated the same. At this point the subjects receiving massed inspection trials (M-groups) rubbed the block for a total of eight minutes. These eight minutes were broken up into 16 thirty-second inspection periods separated by two-second rest periods. Subjects receiving the spaced inspection trials (S-groups) also rubbed the inspection stimulus for a total of eight minutes, but for these groups the 16 thirty-second trials were separated by thirty-second rest periods. During the rest period, the subject relaxed with his hands at his sides. After the inspection period all subjects made four post-inspection judgments in the same order (DAAD) as the pre-inspection judgments.

The subjects in groups 1 (M-15) and 2 (S-15) returned 15 minutes after the last post-inspection judgment for retesting. The subjects in groups 3 (M-24) and 4 (S-24) returned for retesting 24 hours later. (This time varied from 20 hours to 27 hours, but the greater number of subjects returned between 23 and 25 hours later with 24 hours being the median.) Finally, the subjects in groups 5 (M-7) and 6 (S-7) returned for retesting after 7 days had elapsed. (Only one subject included in the experiment missed her afternoon appointment and returned a day later for retesting.)

The procedure for retesting was very simple. The subject was blindfolded and led to his previous position. Then, the experimenter read the following retest instructions:

Retest Instructions

"Today," (Use the word "now" for 15 minute groups instead of "today.") "you are going to make some more judgments. Again it is important that you make the judgments on the basis of how the objects feel to you now."

"Okay, let's get your fingers in the grips like the last time." (Adjust grips and check with S). "Adjust the variable width to equal the constant width in your (non-dominant) hand. Remember to press your fingers against the sides of the objects when you have the two equal in width. Begin here. Make these judgments as quickly and accurately as you can. Take your hands off when you have finished a judgment. Okay. Go ahead."

When the last retest judgment was completed and recorded, the subject was told to remove his blindfold. He was permitted to see the apparatus and was told in a general way that rubbing the inspection block is supposed to affect his subsequent judgments in some way. The purpose of the retest was explained as simply a follow up to see if there was any change in judgments after a lapse of time.

Scoring. - Each subject's judgment of equality of the width of the two blocks (PSE) was recorded in whole numbers. The zero point was set at the one inch point on the ruler. Thus, a score of 10 would objectively be equal to 1 and 10/32 inches. A score of 32 would be equal to 2 inches, and a score of 40 would be equal to 2 and 8/32 inches, etc.

Each subject made 4 pre-inspection judgments, 4 post-inspection judgments, and 4 retention judgments. The mean of each set of four judgments constituted a point of subjective equality (PSE). For each subject the difference between the pre-inspection PSE and the post-inspection PSE was calculated. The differences between the pre-inspection PSE and the retention PSE were also computed. Finally, the difference between the post-inspection PSE and the retention PSE was obtained. Consequently, there are 3 difference scores for each subject, and these difference scores are used in the analysis of the data. Because some of these differences are negative (in the "wrong" direction), a constant of 14.00 was added to all difference scores and made all scores positive.

Results

Distribution of Inspection Trials and the Post-Inspection After-effects.

All the S's were treated alike through the measurement of the post-inspection PSE except for the spacing of the inspection trials. Thus, there were two groups of 57 S's, a massed group and a spaced group.

The post-inspection after-effect was .194 inches (S.D. = .212 in.) for the massed condition and .188 inches (S.D. = .166 in.) for the spaced condition. The significance of this difference was evaluated by a t-test. The obtained value of t was 1.32 which with 112 df is not significant at the .05 level.

It appears that the spacing variable, as manipulated in this experiment, had no significant effect on the KAE after eight minutes of kinesthetic inspection.

Retention of KAE. - The experiment was designed to study the retention of KAE as a function of two variables: time since inspection trials and the spacing of inspection trials. The data subjected to analysis consisted of retention after-effect scores, i.e., the difference between pre-inspection and retention PSE's. The mean retention after-effects and the standard deviations for each of the 6 groups are found in Table 2 which follows on the next page.

The results of an analysis of variance of this data are shown in Table 3 which follows on the next page. Results of an F-max test indicated that the assumption of homogeneity of variance was tenable.

TABLE 2

Pre-test ______ Retest

Mean retention KAE and Standard Deviations (inches)

Time since inspection

		15 minutes	24 hours	7 days	Mean
Massed	M	.184	.112	.199	.165
	s	.178	.127	.118	
Spaced	M	.099	.143	.137	.126
	s	.136	.195	.157	
	Mean	.142	.128	.168	

TABLE 3

Retest minus pre-test analysis of variance of retention KAE.

Source	df	SS	MS	F
Spacing of inspection trials (S)	1	43.60	43.60	1.77
Time since inspection (T)	2	33.34	16.67	.68
Spacing X time	2	73.88	36.94	1.50
Within cells	108	2654.19	24.58	
Total	113	2805.00		

It has already been shown that the spacing variable had no effect on the post-inspection after-effect. The analysis of variance presented above suggests that there is no significant effect of spacing on the retention of after-effect either.

Especially noteworthy is the failure to find any significant differences in the retention after-effect at different intervals. This is surprising when one stops to consider the number and variety of objects that are felt or held between the fingers in a week's time. The implication seems to be that the distortion of judgment which results from the establishment of KAE is a special experience, which is not subject to interference by other holding or feeling experiences the subject might have.

An alternate way of analyzing the data is to use the post-inspection PSE as a base line. Thus, the difference between the post-inspection PSE and the retention PSE makes up the retention after-effect scores. These mean retention AE and standard deviations are shown in Table 4 which follows on the next page.

A negative mean indicates that the PSE's at the retention test were larger on the average than the PSE's at the post-inspection test. In other words, the PSE's grew instead of decreasing in size as would be expected with the passage of time.

The results of the analysis of variance of this data are shown in Table 5 which follows on the next page. Again a non-significant F-max test permitted the assumption of homogeneity of

TABLE 4

Post-test ______ Retest

Mean retention of KAE and Standard Deviations (inches)

Time since inspection

		15 minutes	24 hours	7 days	Mean
Massed	M	.028	.105	-.046	.029
	s	.112	.192	.171	
Spaced	M	-.029	.046	.046	-.009
	s	.137	.170	.213	
Mean		-.0005	.075	.000	

TABLE 5

Post-test minus retest analysis of variance of retention KAE.

Source	df	SS	MS	F
Spacing of inspection trials	1	1.85	1.85	.06
Time since inspection	2	150.14	75.07	2.54
Inspection X time (S X R)	2	147.28	73.64	2.49
Within cells	108	3195.43	29.59	
Total	113	3494.70		

None of the obtained F values were significant at the .05 level.

variances to be made with reasonable assurance.

Again, neither of the main effects nor the interaction was significant. The two ways of analyzing the retention AE data seem to have the same results even though different base lines were used.

Correlational Analysis. - A correlation was computed between the post-inspection after effect and the retention AE, i.e., pre-post with pre-retention for all subjects combined. A Pearson r of .51 was obtained. This was significant at the .01 level with N = 114 and suggests a positive relationship between the size of the post-inspection AE and the retention AE. These results agree with similar r's obtained by Bakan.[2]

To obtain a measure of stability of the KAE, reliability coefficients were computed. These consisted of Product Moment Correlation coefficients between the post-inspection and retention scores for each of the time intervals. Thus, the 15-minute group (N = 38) had an r of .69, the 24-hour group an r of .46 and the 7-day group an r of .47. The 15 minute group would be expected to be the most stable, but it appears that the stability of the scores after 7 days does not differ from the stability after 24 hours. A Fisher Z transformation was used to test for significance between the correlation coefficients. These tests were not significant at the .05 level.

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[2]Personal communication

To assess the effect of the size of the pre-inspection PSE on the size of the KAE, two other correlations were computed. The pre-inspection PSE correlated with the post-inspection AE to the extent of $r = -.47$. The correlation of the pre-inspection PSE with the retention AE was $r = -.51$. These correlations indicate that the larger the pre-inspection PSE, the smaller were the after-effects.

Discussion

Distribution of Inspection Trials and Post-Inspection After-effects.

There were no significant differences between the massed groups and the spaced groups. Bakan[3] reported similar findings with the use of different lengths and number of inspection trials. There may be several explanations for these findings. One possibility is that the distribution of trials has no effect on after-effects under any circumstances. A second possibility is that when many inspection trials are given, rest periods of 30 seconds between trials are not long enough to allow the obstacles to satiation to dissipate. Köhler and Fishback (1950) reported definite improvement in the rate of destruction of M-L Illusion after rest periods of hours or days. They attribute this "reminiscence effect" to the dissipation of "satiation in the wrong places." In view of the findings of the present study that KAE showed no loss in size after a week, it seems plausible that "satiation in the wrong places" may last for long periods also.

If, on the other hand, satiation is synonymous with reactive inhibition, the observation that the massed group tended to have the larger KAE would be as expected. However, this tendency was in contradiction to Bakan's findings that the spaced condition tended to produce the larger after-effects. The trends were not significant in either case, and more investigation is needed to decide

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[3] Personal communication

whether or not the distribution of the inspection trials has any appreciable effect on the size of KAE.

<u>Retention of KAE</u>. - There were no significant differences in the retention after-effect at the different retention intervals. This suggests that the spacing variable did not affect the retention after-effect as would have been expected. These results, of course, make it difficult to talk about the theoretical implications of a differential loss in retention after-effect. A decrement of one kind or another might have been expected from either the memory trace or the reactive inhibition viewpoints.

However, the permanence of the after-effects suggests that of the two viewpoints, I_R and memory traces, the latter was the better explanation of the results in this case. Even though the spacing variable had no effect on the after-effects, the persistence of the KAE was in accordance with the learning type phenomena (memory traces). On the other hand, if the after-effects were produced by I_R there should have been some decrement in size after a week. This follows from the postulation by Hull (1943) and others that reactive inhibition dissipates relatively quickly.

Another factor in favor of the memory trace explanation is the observation by other investigators that for some types of learning, the distribution of practice has no effect on performance. For instance, the difference in performance does not show up in some types of verbal learning when the massing-spacing variable is manipulated. Memory is usually crucial in such experiments. Perhaps the establishment of KAE is similar to the processes involved in verbal learning.

On a less theoretical basis, there are several possible explanations for finding no decrease in the size of the retention AE for longer periods of time. One is that KAE is much more permanent than has been suspected, i.e., our longest retest interval of 7 days was too short for dissipation of the effects of eight minutes of inspection.

A second explanation is that a total of eight minutes inspection has an intense effect on the neural tissue presumably involved, and recooperation from this effect takes a long time. In connection with this possibility the KAE's obtained in this study were considerably larger than the after-effects obtained in studies using smaller amounts of inspection. In either event, future investigations of the retention variable should consider having either less inspection or a longer retest interval or both.

The persistence of the KAE over a period of a week, in spite of the numerous kinesthetic experiences a subject would have in that length of time, suggests that the establishment of KAE is specific to the experimental situation. That is, other experiences do not seem to interfere with KAE. Helson (1947) has reported a similar type of specificity in the development of adaptation level for the judgment of weights. This occurred when he introduced a weight that was clearly not a part of the series the subject was judging at the time of introduction. He found that it did not influence the adaptation level.

Correlational Analysis. - There was a significant correlation of .51 between the size of the immediate after-effect and the retention after-effects. This positive relationship implies that the size of a subject's retention after-effect could be reasonably predicted from the size of his immediate after-effect. The reliability of such a prediction decreased from a correlation of .69 at the 15 minute interval to a correlation coefficient of .46 and .47 for the 24 hour and 7 day intervals respectively.

Another interesting relationship was the negative correlations between the size of the pre-inspection PSE and both the immediate and retention after-effects. This indication that large pre-inspection PSE's are related to small KAE's can be explained in two ways. One possibility is that subjects who have large pre-inspection PSE's can not make significantly larger post-inspection or retention PSE's because of the anatomical structure of their hand and/or the construction of the test stimulus. In connection with this possibility a few individuals exhibited amazingly large PSE's at all tests.

A second possibility is that the subjects with large pre-inspection PSE may have a high level of permanent satiation, and thus the inspection is less effective. Kohler and Dinnerstein (1947) have suggested that everyone has a permanent level of satiation. Individual differences in this permanent level would certainly be expected. However, more definitive evidence than is presented in this study would be needed to confirm either of the above mentioned possibilities.

Summary

This experiment was an attempt to formulate and test certain expectations which were derived from two contrasting positions: (1) that KAE is a learning type phenomenon and that satiation is a neural change similar to a memory trace, and (2) that KAE is produced by a process similar to or synonymous with reactive inhibition.

The derived expectations were based on the assumptions that massed versus spaced inspection trials would lead to different results in the size of KAE. It was further assumed that the retention of KAE would be affected in different ways by the distribution of inspection trials.

To test the derived expectations, the following experiment was designed. Six groups each consisting of 19 subjects were individually tested for KAE. Each subject made judgments of the equality of widths of two blocks of wood. These judgments were made in series of four immediately before the inspection period (pre-test), immediately after the inspection period (post-test), and after a specified amount of time had elapsed since inspection (retest).

All subjects received 16 thirty-second inspection trials. For half the subjects these trials were massed, and for the other half the trials were spaced. Then one of the massed inspection groups and one of the spaced groups each returned for retesting after intervals of either 15 minutes, 24 hours or 7 days.

The difference scores between the pre-test and post-test PSE's were the immediate KAE's. The difference scores between the pre-test and the retest PSE's as well as the difference between the post-test and retest PSE's were used as measures of retention after-effects.

A t-test and two analysis of variance designs using these difference scores attempted to test the above mentioned expectations. None of these tests were statistically significant, and thus, the basic question as to whether KAE's are produced by a learning type phenomena (memory traces) or by reactive inhibition could not conclusively be answered but the evidence was in favor of the learning type explanation. The following results were obtained:

1. Distributing the inspection trials had no significant effect on the size or persistence of KAE's.

2. A total of eight minutes of inspection established relatively large KAE's which did not decrease in size after an interval of a week. This is in contrast to the persistence of most visual after-effects. Also, there is an indication that KAE's are a specific experience which is not affected by ordinary day to day use of the hands.

3. A correlation of .51 was obtained between the immediate after-effects and the retention after-effects. Stability coefficients for this relationship indicated that KAE's are most stable

after 15 minutes but could be reliably obtained after intervals of 24 hours or 7 days.

4. Negative correlation coefficients of -.47 and -.51 were obtained between the size of the pre-inspection PSE and the size of the immediate KAE and the retention KAE respectively. This meant that subjects with large pre-inspection PSE's tended to have small after-effects.

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