FACTORS INFLUENCING KINESTHETICALLY GUIDED MOVEMENTS OF HEAD AND ARM

by

EUGENE SINCLAIR EDGINGTON

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INTRODUCTION

The kinesthetic sense is that sense concerned with "sensations attending movements of any members of the body which arise from stimulation of special receptors situate in the muscular tissue, joints, and tendons, the stimulus being some mechanical effect of the contracting muscle or moving members." (Warren, 1934). Scott (1942) stressed the importance of kinesthesis in motor activity. She emphasized the fact that the learning of motor skills is dependent upon kinesthesis, because without kinesthesis there is no feeling of position or movement, both of which are involved in motor skills.

Washburn (1916) wrote a book about the relationship of bodily movement to mental imagery. She believed that the kinesthetic sense played an important role in thinking. Dunlap (1912) stated, "Some persons find a great decrease in facility of visual imagination when the eyes are under the influence of atropine..." He maintained that sensations of accommodation are important in making mental pictures, in these persons.

Having subjects estimate the extent of movement of an arm was one method of kinesthetic research used by early prominent psychologists. Abel (1936) stated that Fechner, Wundt, and Jastrow were among the earlier investigators in testing the accuracy with which estimates of extent can be

made.

Jastrow (1886) compared the judgments of linear extension made by the eye, hand and arm, and determined their relative accuracy in his experiment. The method consisted in presenting a definite length to one of these senses of the subject, who was then required to adjust a second length equal to the first by the use of the same or another sense. The judgments were confined to lengths between 5 and 120 millimeters.

Leuba (1909) also studied the judgment of extent of movement. He maintained that a gradual increase in the resistance offered to a movement produces a decrease in the rapidity of the movement; he believed that this decrease in rapidity of movement is underestimated, causing an overestimation of the length of movement that takes place.

The term "passive movements" is sometimes used in literature on the kinesthetic sense. A passive movement is a movement of some part of the subject's body without effort on the part of the subject; an example is the moving of a subject's relaxed arm by an experimenter. Greenwood (1910) discussed passive movements. He said that in right-handed persons, if the right and left hands were passively moved through the same distance, that the subject thought the left hand moved farther. For left-handed people, the opposite result was obtained.

The influence of load on kinesthesis was discussed by

Weber (1927). Kinesthetic perception of the distance moved and of the time taken to move a certain distance were found to be influenced by the load or restraining force applied to the organ being moved. Weber said, "A given distance under load is phenomenally equivalent to a greater distance under less load. A given time-interval under load is phenomenally equivalent to a smaller time-interval (as measured by clock-time) under less load."

Loemker (1930) designed an experiment to determine the influence of head position and the position of an object in the visual field in making a localizing arm response to a visible object in a horizontal plane. The subjects made localizing responses over a range of 40 centimeters. He concluded, "Head position in relation to eye axes was a significant factor determining the accuracy of the localizing response." He also mentioned that the position of the object in the visual field affected the direction and size of the error of localization.

Fitts (1947) made a study of subjects reaching to targets mounted about them at distances of 30 inches from the midpoint of the shoulders. Vision of both the target and the body was excluded. The subjects were not allowed to turn in the direction in which they were reaching; at all times during the experiment their vision was fixed upon a single reference point directly in front of them. "When the data was analyzed

in terms of the average accuracy of location discrimination, it was found that accuracy was best for forward areas." Individuals tended to reach too low for targets above the level of their shoulders, too high for targets below shoulder level, and too far to the rear for targets located on either side. "The directional characteristics of the patterns did not change appreciably with additional practice accompanied by knowledge of results, even though the overall scatter of marks became less."

Brown, Knauft and Rosenbaum (1948) studied judgment of extent of arm movements. They wrote that "little material is available on the ability of individuals to make simple linear, rotary, or repetitive movement of the articulated members of the body." Their study in judgment of extent was concerned with movement in four directions in the horizontal plane and two directions in the vertical plane. They found that for all six conditions the variability of judgments increased significantly with distance.

Experimental research was conducted for this thesis for the purpose of obtaining more knowledge about the kinesthetic sense. More specifically, the research was concerned with the ability of an individual to look where he is pointing or to point where he is looking, when vision of his pointing hand and arm are excluded. The influence of certain factors upon the localizing responses was studied. Experiment I was to be the only experiment written up in this thesis; however,

the statistical analysis of the data for Experiment I gave the experimenter some hypotheses to be tested in Experiment II.

MATERIAL AND METHODS

A localization apparatus, a sight tube, pointers, and Form I data sheets were the materials used in Experiment I. For Experiment II, the localization apparatus, pointers, and Form II data sheets were used; the sight tube was not used in Experiment II. The localization apparatus, sight tube, and Form I and Form II data sheets are shown in the Appendix. Two pointers were used, one for the forefinger of each hand. Each pointer was a small, thin piece of metal that was taped to the subject's forefinger so as to extend ½" beyond the end of the finger, in the center of the longitudinal axis of the finger.

Twenty subjects were used in Experiment I and 20 other subjects were used in Experiment II; no subject was used in both Experiment I and Experiment II. The subjects were male college students between 18 and 30 years of age, whose arm reach was sufficient to reach the backplate of the localization apparatus while seated. None of the subjects was aware of having any deformity which prevented normal movement of the head, arm, or hand; subjects with stiff necks, sore arms, etc. were not used in the experiments. Subjects with poor

vision were not used. The subjects in both experiments were told only that the experiment required two sessions of about 40 minutes each, and that the experiment was concerned with eye-hand coordination. They were not given any information concerning their own localizing responses or the localizing responses of others until all of the data had been obtained from the 20 subjects for the experiment.

The two sessions required for each experiment were scheduled to allow two to seven days between sessions. The subjects were asked not to practice making localizing responses or to discuss the experiment with anyone during the interim. After the second session was completed, the subjects were again asked not to discuss the experiment with anyone.

The sequence of the localizing responses was randomized to nullify the effect of sequence upon the data obtained. The numerical sequence in which the localizing responses were to be made was indicated in the margin of the data sheet, to aid the experimenter.

The procedures for Experiment I and Experiment II, that follow, are the same for both sessions. Localizing responses were made with each arm; the right arm was used for localizing responses on the right half of the localization apparatus (as seen by the subject seated at the apparatus), and the left arm was used for localizing responses on the left half. Localizing responses were made toward comparable positions for the right and left halves, making a localizing

response with only one arm at a time, however. The procedure for the left arm and the left half of the apparatus corresponds to the procedure for the right arm and the right half of the apparatus, so only the procedure for the right side will be given here. Verbatim instructions are in quotation marks.

Procedure for Experiment I

The purpose of Experiment I was to determine the effect of head position in relation to body position on the magnitude, variability, and direction of errors made in making localizing responses with the head and with the arm. The two distinct operations performed in Experiment I will be called Moving and Stationary because in one operation the arm is moving and in the other operation the arm is stationary. A Moving localizing response is made by a subject when he moves his hand away from his body and points where he is looking. A Stationary response is made when the subject turns his head to look where his hand has been placed against the backplate of the apparatus.

The purposes of certain parts of the procedure are given below:

1. To determine the hand with which a subject prefers to point.
2. To minimize the possibility of tactual reference points.

3. To discourage the subjects from making visual estimates of the angle formed by the movement of the head by using the front marker at position F as a reference point.
4. To control the head position in relation to the eye axes.
5. To control the head position in relation to the body.
6. To control what might be an influential factor: passive versus non-passive movements.
7. To minimize backplate reference points.
8. To prevent the feeling of inaccuracy that a subject gets when he turns his head back front while his hand is still against the backplate.

At the beginning of the session the subject was told to stand at a designated location and look, without spectacles, to the front at a paper strip on which there were typewritten letters. "Point to the combination of letters in which there is a 'T' on the top with an 'O' underneath it." Subjects who had difficulty in locating the combination of letters were not used in the experiment. The T over O combination was directly in front of the subject, as near to one arm as to the other. The hand with which the subject pointed was considered to be his preferred hand and this was recorded inconspicuously on the data sheet, after "handedness in pointing". (Purpose 1).

The experimenter then attached the pointers to the subject's right and left forefingers. (Purpose 2) The pointers were held to the fingers with masking tape. The subject was told to sit on the piano stool at the localization apparatus. The stool was adjusted in height until the subject's lower lip was just above the partition. When this was done the experimenter attached the sight tube to the subject's head. (Purpose 3 and Purpose 4)

The subject was instructed to adjust his body position until his head and body were facing an indicated marker (position F on the backplate). "The marker at which you are looking is our reference point; when I say 'back front' I mean turn back to this marker. Always keep your body facing the front."

Stationary Operation. "I'm going to place your right hand to the right of you. When I tell you to turn, turn your head, not your body, to the right until you are looking where you are pointing." (Purpose 5) The subject was then told to relax his arm, while keeping the forefinger in a pointing attitude. (Purpose 6) The experimenter grasped the subject's hand and his arm just above the elbow and moved them straight from the subject's body to a predetermined location on the backplate, on scale 3, at the bottom edge of the partition. "Now hold your arm tense; brace it against this partition so that it won't move." The experimenter then told the subject to turn to the right until he

was looking where he was pointing. When the subject stopped turning his head, the experimenter lifted the cardboard screen (Purpose 7) and asked the subject to read the top and then the bottom letter from the paper strip where he was pointing. The experimenter repeated the letters as a check. "Take down your hand .... swing back front." (Purpose 8) The Stationary operation for position F, directly in front, required no turning, so the subject was told to keep looking to the front and a cardboard screen was placed between him and the front marker. Then the subject's relaxed hand was placed, the cardboard screen was lifted, and the subject read the letters.

Moving Operation. "I'm going to place a marker to the right of you; this marker looks like the one in front of you. When I tell you to turn, turn your head, not your body, to the right until you see the marker; then point with your right hand to the marker; when you point, slide your hand along the underside of this partition. At arm's length you will touch the backplate." The subject was then instructed to turn to the right, and to point with his right hand. The experimenter read the location of the subject's hand from scale 2, and recorded the location on the data sheet. "Take down your hand .... swing back front." The Moving operation for position F, directly front, required no turning, so the subject was told to look straight at the marker in front of him and point to it.

Procedure for Experiment II

The purpose of Experiment II was to determine whether the undermovement of the head (head not turning far enough out) in the Stationary operation of Experiment I was due to either the weight of the eye tube or the outward swinging movement of the head.

Various elements of the procedure for this experiment which are identical with elements of Experiment I procedure serve the same purpose in both experiments. As the subject wore no sight tube in this experiment, the experimenter attempted to control the position of the head in relation to the eye axes by instructions and by close observation of the head and eye movements.

Experiment II may be divided into four operations: Swinging Hand Out, Swinging Hand In, Swinging Head Out, and Swinging Head In. Swinging Hand Out and Swinging Hand In are almost the same as Moving in Experiment I; a major difference is the swinging movement of the hand in pointing to the marker in contrast to the movement of the hand straight from the body in Moving. Swinging Head Out and Swinging Head In are similar to Stationary, except that in the case of Swinging Head In, the head starts from near the outer edge of the apparatus and turns toward the front when it turns where the hand is.

Swinging Hand Out. "I'm going to place a marker to the

right of you; this marker looks like the one in front of you. When I tell you to turn, turn your head, not your body, to the right until you see the marker; face the marker squarely and keep looking at it while I place your hand against the backplate. Then wait until I tell you to swing your arm; when I do, swing your arm out until you are pointing to the marker. When you swing your arm, swing it freely in the air; don't drag it against any part of the apparatus. Swing it as fast or as slow as you like, but when you stop swinging it push your hand against the backplate. Don't move your hand after you touch the backplate. Swing your hand in just one direction; don't swing your hand past the marker and then swing it back." After a slight pause, the experimenter continued, "Turn your head, not your body, to the right." Then the experimenter passively moved the subject's arm as in Experiment I. He placed the subject's pointed finger on scale 3 at position F and said: "Now hold your arm tense; brace it against this partition so that it won't move." The subject was then directed to swing his arm out and point to the marker, which was at position C or D. After recording the location of the subject's hand, the experimenter said, "Take down your hand .... swing back front."

Swinging Hand In. In this operation the passive hand was placed at position A instead of position F; otherwise the procedure for Swinging Hand Out was the same as for

Swinging Hand In, with the use of the words "in" and "out" where appropriate.

Swinging Head Out. "I'm going to place your right hand to the right of you. When I tell you to turn, turn your head, not your body, to the right until you are looking where you are pointing." The experimenter passively placed the subject's hand at position C or D on scale 3. "Now hold your arm tense; brace it against this partition so that it won't move." Then the experimenter said, "Turn your head, not your body, out until you are looking where you are pointing." When the subject stopped turning his head, the experimenter lifted a cardboard screen and told the subject to read the top and then the bottom letter from the paper strip where the subject was pointing. The experimenter repeated the letters, as a check. "Take down your hand ....swing back front."

Swinging Head In. "Turn your head, not your body, to the right until you see a marker that looks like the one in front of you. Keep looking at that marker until I give you further instructions. Look at it squarely." The marker to which the subject turned was at position A. The rest of the procedure was the same as for Swinging Head Out, with the appropriate substitution of "in" and "out" in the instructions.

Statistical Methods Used in the Analyses of Data

The comparison of two operations by the statement that "this operation is more accurate than that one" is useless unless the method of computing and comparing accuracies of the operations is given. Statements concerning accuracy should always include a definition of accuracy; for example, "accuracy" may refer to the size of the mean error, to the variability of the errors, or to the tendency for more errors to occur in one direction than in another. The experimenter believed that the results of Experiments I and II could be presented more clearly if the word "accuracy" were not used; the results are presented in such a manner that the reader may study them in relation to his own definition of accuracy.

The analyses of the data of the two experiments was primarily for the purpose of detecting differences in magnitude, variability, and direction of errors of localization made under different conditions. As the readings on the data sheets were recorded directly from the scale on the localization apparatus, and from the letters read by the subject, these readings had to be transformed to indicate the size and direction of error. The direction of the errors was indicated for all of the operations, in both experiments, in this way: a $+$ error if the location of the hand was outside the location of the head toward the edge of the apparatus,

and a - error if the hand was inside the location of the head (as indicated by the letters read) toward the center of the apparatus. The techniques involved in the analyses of the data are explained in "Statistical Methods" by Snedecor (1946).

RESULTS OF EXPERIMENT I

Snedecor's F test showed that the difference in variability between Moving and Stationary, within position, person, and side, that is, taking position, person, and side into consideration, was statistically significant beyond the .001 level of confidence; therefore, further analysis of the data had to be performed for Moving and Stationary, separately.

Bartlett's test for homogeneity of variance (Snedecor, 1946) showed that for Moving there was non-homogeneity of variance among positions; however, two homogeneous groups were obtained by placing positions A, B, and C in one group and positions D, E, and F in another group. For Stationary, non-homogeneity among positions was found to exist. Position C showed the greatest variation for Stationary, while position F showed the least variation.

As some of the non-homogeneity in the preceding instances may have been due to the difference in variability within the three individual readings, the same test of homogeneity of

variance in terms of "total error" (see Form I in the Appendix) was performed; however, a preliminary analysis of preferred and non-preferred hands, in regard to the size of errors made, was calculated to find out whether the data for preferred and non-preferred hands could be pooled.

The method of paired comparison (using "total error" figures) was used to determine whether there was a significant difference between the errors made with preferred and non-preferred hands, within position. No significant difference between preferred and non-preferred hands was found for Moving. The same was true of Stationary, with the exception of position D, which showed a difference between preferred and non-preferred that was significant at the .05 level. As one out of 20 paired comparison tests will show a difference that is significant at the .05 level of confidence, simply by chance, it is quite reasonable that this difference between preferred and non-preferred hands for position D was due to chance.

Using "total error" terms, it was found that for Moving, the person-to-person variability was homogeneous between positions at the .05 level of confidence. For Stationary, the variances for the six positions were significantly different at the .05 level.

Table 1 shows that Stationary had significantly greater variability than Moving for position A, position B, and position C. Positions D, E, and F, which are the three positions

nearest the front of the localization apparatus, showed no significant difference between the variability for Moving and the variability for Stationary. The direction of error in Moving and Stationary operations was considered to be of importance, so the mean errors of Moving and Stationary operations for each position were calculated and the 95 per cent confidence interval for each mean error was determined.

Table 1. Ratios of Moving and Stationary variances for each position.

Position	F Ratio of variances	Greater variance
A	3.35*	Stationary
B	3.99**	Stationary
C	3.92**	Stationary
D	1.58	Stationary
E	1.11	Stationary
F	1.28	Moving

* .05 level of confidence
** .01 level of confidence

Undermovement, in this experiment, means that the error was toward the front of the localization apparatus; overmovement, in this experiment, means that the error was toward the outer edge of the apparatus. The t test showed that the differences between the means of positions A, B, C, D, and E for Stationary were not significant at the .05 level; therefore, although there is undermovement for each of those five positions for Stationary, there is no evidence

of more undermovement for one of the five positions than for any of the other four positions.

Table 2. The mean errors for Moving and Stationary and their confidence intervals for each position in terms of quarter inches.

Position	Moving mean error	Stationary mean error	95% Confidence intervals: Moving	Stationary
A	-5.5	±4.6	-7.4 to -3.6#	±1.3 to ±7.9#
B	-1.2	±6.9	-3.0 to ± .6	±3.7 to±10.1#
C	± .3	±5.3	-1.5 to ±2.1	±1.8 to ±8.8#
D	- .4	±2.3	-2.2 to ±1.4	± .1 to ±4.5#
E	±3.4	±2.5	±1.6 to ±5.2##	±1.0 to ±4.2#
F	- .3	± .4	-2.0 to ±1.4	- .6 to ±1.4

\# significant undermovement
significant overmovement

For Moving, the difference between the mean errors for position A and any other position was significant at the .01 level. The difference between the mean errors for position E and any other position was also significant at the .01 level.

RESULTS OF EXPERIMENT II

Snedecor's F test showed that the difference in variability between Swinging Hand and Swinging Head, taking into consideration hand, direction of swing, and position, was significant at the .01 level of confidence. Swinging Head

showed the greatest variability.

Table 3. The mean errors and confidence intervals for Experiment II in terms of quarter inches.

Operation performed	Hand	Position	Direction of swing	Mean error	95% Confidence interval
Swinging Hand	Non-preferred	C	In	≠ 4.7	-4.4 to ≠13.8
Swinging Hand	Preferred	C	In	≠10.1	≠1.0 to ≠19.2#
Swinging Hand	Non-preferred	D	In	≠ 8.1	-1.0 to ≠17.2
Swinging Hand	Preferred	D	In	≠11.8	≠2.7 to ≠20.9#
Swinging Hand	Non-preferred	C	Out	-18.5	-27.6 to -9.4#
Swinging Hand	Preferred	C	Out	-13.5	-22.6 to -4.4#
Swinging Hand	Non-preferred	D	Out	-16.6	-25.7 to -7.5#
Swinging Hand	Preferred	D	Out	- 8.9	-18.0 to ≠ .2
Swinging Head	Non-preferred	C	In	- 9.8	-18.9 to - .7#
Swinging Head	Preferred	C	In	- 7.1	-16.2 to ≠2.0
Swinging Head	Non-preferred	D	In	-13.3	-22.4 to -4.2#
Swinging Head	Preferred	D	In	-11.9	-21.0 to -2.8#
Swinging Head	Non-preferred	C	Out	≠ 7.8	- 1.3 to ≠16.9
Swinging Head	Preferred	C	Out	≠ 9.8	≠ .7 to ≠18.9#
Swinging Head	Non-preferred	D	Out	≠ 2.1	- 7.0 to ≠11.2
Swinging Head	Preferred	D	Out	≠ 4.7	- 4.4 to ≠13.8

significant undermovement
L. S. D. (.05) is 12.9

Undermovement shown in Table 2 means errors made due to the head or hand not swinging far enough in making a localizing response. Undermovement is apparent for both Swinging Hand and Swinging Head, and for both In and Out for either Swinging Hand or Swinging Head. "L. S. D. (.05) is 12.9" means that the least difference between mean errors in the table that is significant at the .05 level is 12.9. For example, the difference between the mean errors for Swinging Hand Non-preferred C In and Swinging Hand Preferred C In is ⁄10.1 minus ⁄4.7, or 5.4; as 5.4 is less than 12.9 the difference between the mean errors for the two conditions is not significant at the .05 level. An example of a significant difference between mean errors is Swinging Hand Non-preferred C In and Swinging Hand Non-preferred C Out. The difference is ⁄4.7 minus -18.5, or 23.2, which is greater than 12.9 and, therefore, significant at the .05 level of confidence.

By the use of the least significant difference (12.9), it can be seen that for the same operation, same position, and same direction of swing, the mean errors for preferred and non-preferred hands are not significantly different. For the same hand, same position, and same direction of swing, there is a significant difference between Swinging Hand and Swinging Head in every instance. There is a significant difference between the mean errors for Swinging In and Swinging Out, for the same operation, same hand, and same position.

As regards mean error, there is no case of a significant difference between C and D positions, for the same operation, same hand, and same direction of swing.

Determining whether changing one condition in an experiment produces a significantly different mean error is one method of finding out whether the condition appreciably affected the results of the experiment. It is possible that changing one condition in an experiment might produce no significant change in the mean error, but might produce a different variability about the mean error. It was shown that the difference in mean errors for positions C and D was not significant at the .05 level. To find out whether the two positions produced a different variability about the mean error, Bartlett's test of homogeneity of variance was applied. In performing the test of homogeneity of variance, the operation performed, direction of swing, and the hand used were taken into consideration.

Table 4. Ratios of position C variances to position D variances.

Operation performed	Hand	Direction of swing	F Ratio of "C" variance to "D" variance	Larger variance
Swinging Hand	Non-preferred	In	4.10**	D
Swinging Hand	Preferred	In	1.08	
Swinging Hand	Non-preferred	Out	1.06	
Swinging Hand	Preferred	Out	1.84	
Swinging Head	Non-preferred	In	4.07**	C
Swinging Head	Preferred	In	1.84	
Swinging Head	Non-preferred	Out	2.63*	C
Swinging Head	Preferred	Out	2.15	

* .05 level of confidence
** .01 level of confidence

Table 4 shows that, under certain condition, the variability for position C was significantly different from the variability for position D.

DISCUSSION

Experiment II indicated that part of the non-homogeneity of variance between Moving and Stationary (Experiment I) might be due to the fact that the head was swinging outward in making localizing responses in Stationary, whereas the hand was moving straight away from the body in Moving.

For positions A, B, and C, considered individually, Stationary showed significantly greater variation than Moving. This may be due to conditioning, as it is probably more customary to point where one looks than to look where one points. Positions D, E, and F showed no significant difference in variances between Moving and Stationary; this may have been because the front area was fairly easy for both operations. Stationary showed undermovement tendencies for all positions except F; there was no significant difference in the amount of undermovement for the five positions showing the undermovement tendency.

No significant difference was found in Experiment I between the mean errors for preferred and non-preferred hands. The same was true in Experiment II. Experiment II showed undermovement for both Swinging Head and Swinging Hand, for

In and for Out. Upon discovering the undermovement tendency in the analysis of the data, the experimenter thought that the part of his instructions stating, "Don't swing your hand past the marker and then swing back" might have been interpreted to mean that it would be better to make an error of undermovement than an error of overmovement, with the swinging hand. To check this assumption, he wrote the following and gave it to the subjects who had been used in Experiment II:

"Try to remember the part of the eye-hand coordination experiment in which you were to swing your arm and point to the marker. In swinging your arm, were you more cautious

(a) in making sure you swung it far enough.

(b) in making sure you didn't swing it too far.

(c) same amount of caution for both (a) and (b)?"

The data for the subjects who answered (a) or (c) were considered one group and the data for the subjects who answered (b) were considered a separate group. No significant difference of variability, within position, person, side, direction of swing, and operation, was found between the two groups. The t test showed no significant difference of the mean errors of the two groups. As no difference of means and no difference of variability was found between the two groups, the groups were combined for the analysis of the data in "Results of Experiment II".

Relationship of the Findings to Previous Knowledge

It would be futile to attempt to verify or refute the results of an earlier investigator of the kinesthetic sense by referring to the results obtained from this investigation; the apparatus and procedure for this study were different from those used in previous experiments. This experiment adds more evidence of the complexity of coordinations involving the kinesthetic sense. How the outcomes of this study are related to those of previous studies is indicated by the following list of factors found by various investigators to influence the kinesthetically guided movements of the head or of the arm, or the coordinated movements of head and arm:

1. Resistance to a movement. (Leuba, 1909)
2. Preferred and non-preferred hands. (Greenwood, 1910)
3. Load. (Weber, 1927)
4. Head position in relation to eye-axes. (Loemker, 1930)
5. Position of object in the visual field. (Loemker, 1930)
6. The plane in which the movement occurs. (Brown, Knauft, and Rosenbaum, 1948)
7. Distance through which movement takes place. (Brown, Knauft, and Rosenbaum, 1948)
8. Swinging movement of head. (present study)
9. Swinging movement of arm. (present study)

10. Position of the head in relation to body position. (present study)

The above list of factors that have been found in closely related experiments is not to be considered as comprehensive, but it illustrates the fact that investigators in this field of research have to design and conduct their experiments with care.

Suggestions for Future Research

With little or no modification, the apparatus used in this study could be used to determine the effect of a number of factors upon the kinesthetic impression of the location of some part of the body. Some of the factors to be tested are fatigue, sex, drugs, blindness, age, and pain or discomfort. The acquiring of motor skills requires the duplication of correct responses. The ability to duplicate a correct localizing response can be tested with the localization apparatus. The experimenter believes that an apparatus designed to measure the ability to reproduce an applied force and the ability to duplicate movements in various planes would be of considerable value in determining a person's aptitude for certain motor skills.

SUMMARY

1. Two experiments were conducted to determine the influence of certain factors upon the ability of an individual to look where he is pointing or to point where he is looking, when vision of his pointing hand and arm are excluded.

2. Differences in variability and differences of mean errors were both taken into consideration in the statistical analysis of the data. As differences of mean errors were computed while taking into consideration the direction of the errors, some significant differences of mean errors are due to difference in directions of error, rather than differences in magnitude of error.

3. The following factors were found to influence localizing responses in these experiments: the part of the body making the localizing response (head or arm), the position of the head in relation to body position, swinging movement of head or arm in making a localizing response, and direction of swinging.

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APPENDIX

EXPLANATION OF PLATE I

Design of the Localization Apparatus

The localization apparatus is essentially a sheet of metal curved about and nailed to a piece of fiber board. The metal is known as the backplate and the fiber board is known as the partition. The backplate is so curved that all positions (A, B, C, D, E, and F) on the right half of the apparatus are equidistant from the right shoulder and all positions on the left half are equidistant from the left shoulder; therefore, the backplate is not curved in the form of a true semicircle.

The approximate location of the positions on the backplate used in Experiments I and II are indicated by the letters A, B, C, D, E, and F. Actually, the backplate and partition extended almost a foot beyond position A in the sketch to allow errors to be made between position A and the edge of the localization apparatus.

Considering position F to be 90°, positions A, B, C, D, and E are approximately 5°, 20°, 40°, 55°, and 75°, respectively, with respect to the notch in which the head rests; of course, the angles would be different in respect to the shoulders. The numbers on the data sheets that correspond to the six positions:

Position	Left Side	Right Side
A	10	342
B	36	316
C	80	272
D	106	246
E	150	202
F	176	176

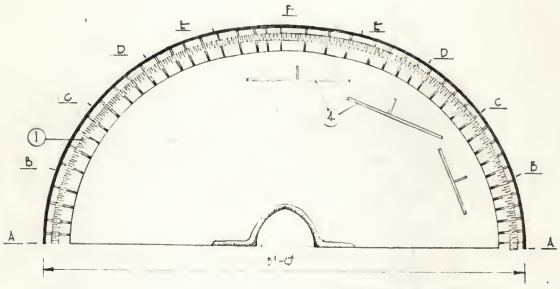
Number 1 on the plate indicates the scale from which the experimenter gets the reading when the localizing response is made with the arm. The location of the hand below the partition is seen between the nails to which scale number 1 is glued.

Number 2 is another scale, being a paper strip of combinations of letters from which the subject reads to indicate where he thinks his hand is, when the localizing response is made with the head.

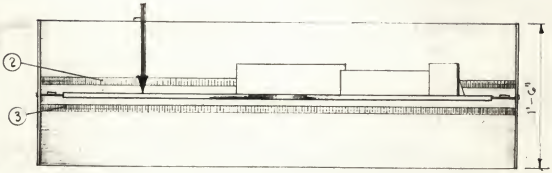
Number 3 is the scale used by the experimenter when he places the subject's hand, when the localizing response requires this procedure. Number 2 and number 3 scales are pasted to the backplate.

Number 2 scale is the only one seen by the subject, and it is only seen when the experimenter lifts one of the cardboard screens (number 4).

PLATE I



TOP VIEW



FRONT VIEW
SCALE 1"=1'-0"

EXPLANATION OF PLATE II

Localization Apparatus in Operation

Plate II shows the moving operation of Experiment I, in which the subject, wearing the sight tube, looked at the marker and pointed to it. Actually, in the experiments, cardboard screens were on each side of the marker, blocking the view of the paper strip with the combinations of letters.

The sight tube limited the peripheral vision of the subject to about 5½" at the distance of the backplate. Although no sight tube was used in Experiment II, the subject could not see his arms or body while he was seated at the apparatus.

PLATE II

SIDE

SIGHT TUBE

FRONT

NAME..... CURRICULUM..... ADDRESS.....

PHONE NUMBER..... HANDEDNESS IN POINTING.....

Date_____

MOVING HAND

Left Side:

Marker Location	Hand Location 1st	2nd	3rd	Total Error
36				
150				
80				

Right Side:

Marker Location	Hand Location 1st	2nd	3rd	Total Error
272				
316				
202				

STATIONARY HAND

Left Side:

Hand Location	Letters Read 1st	2nd	3rd	Letter Loc.	Total Error
80					
150					
36					

Right Side:

Hand Location	Letters Read 1st	2nd	3rd	Letter Loc.	Total Error
202					
316					
272					

Date_____

MOVING HAND

Left Side:

Marker Location	Hand Location 1st	2nd	3rd	Total Error
176				
10				
106				

Right Side:

Marker Location	Hand Location 1st	2nd	3rd	Total Error
342				
176				
246				

STATIONARY HAND

Left Side:

Hand Location	Letters Read 1st	2nd	3rd	Letter Loc.	Total Error
176					
106					
10					

Right Side:

Hand Location	Letters Read 1st	2nd	3rd	Letter Loc.	Total Error
342					
246					
176					

NAME..... CURRICULUM..... HANDEDNESS IN POINTING.....

SWINGING HAND Left Side: Date

Marker		Hand	Hand	Total Error
106	IN			
80				
106	OUT			
80				

Right Side:

Marker		Hand	Hand	Total Error
272	IN			
246				
246	OUT			
272				

SWINGING HAND Left Side: Date

Marker		Hand	Hand	Total Error
80	IN			
106				
106	OUT			
80				

Right Side:

Marker		Hand	Hand	Total Error
272	IN			
246				
272	OUT			
246				

SWINGING HEAD Left Side:

Hand		Letters	Letter Loc.	Total Error
80	IN			
106				
80	OUT			
106				

Right Side:

Hand		Letters	Letter Loc.	Total Error
246	IN			
272				
272	OUT			
246				

SWINGING HEAD Left Side:

Hand		Letters	Letter Loc.	Total Error
106	IN			
80				
106	OUT			
80				

Right Side:

Hand		Letters	Letter Loc.	Total Error
246	IN			
272				
246	OUT			
272				

FACTORS INFLUENCING KINESTHETICALLY GUIDED MOVEMENTS OF HEAD AND ARM

by

EUGENE SINCLAIR EDGINGTON

B. S., Kansas State College
of Agriculture and Applied Science, 1950

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Two experiments were conducted to determine the influence of certain factors upon the ability of an individual to look where he is pointing or to point where he is looking, when vision of his pointing hand and arm are excluded. The purpose of Experiment I was to determine the effect of head position in relation to body position on the magnitude, variability, and direction of errors made in making localizing responses with the head and with the arm. The purpose of Experiment II was to determine whether the undermovement of the head (head not turning far enough out) in the Stationary operation of Experiment I was due to either the weight of the sight tube or the outward swinging movement of the head.

A localization apparatus, a sight tube, pointers, and Form I data sheets were the materials used in Experiment I. For Experiment II, the localization apparatus, pointers, and Form II data sheets were used; the sight tube was not used in Experiment II. The localization apparatus is essentially a sheet of metal curved about and nailed to a piece of fiber board. The metal is known as the backplate and the fiber board is known as the partition. The backplate is so curved that all positions on the right half of the apparatus are equidistant from the right shoulder and all positions on the left half are equidistant from the left shoulder. The sight tube limited the peripheral vision of the subject to about 5½" at the distance of the backplate. Two pointers were used, one

for the forefinger of each hand. Each pointer was a small, thin piece of metal that was taped to the subject's forefinger so as to extend ½" beyond the end of the finger, in the center of the longitudinal axis of the finger. Forty male college students were used as subjects, twenty students for each experiment.

The two distinct operations performed in Experiment I will be called Moving and Stationary, because in one operation the arm is moving, and in the other operation the arm is stationary. A Moving localizing response is made by a subject when he moves his hand away from his body and points to where he is looking. A Stationary response is made when the subject turns his head to look where his hand has been placed against the backplate of the apparatus. The subject was seated at the localization apparatus so as to look above the partition, whereas his hand was beneath the partition, out of his sight. For Stationary operations the head started its movement at the front of the apparatus and moved outward toward the edge of the apparatus. The principal differences between Experiments I and II were in procedure; however, there was one significant difference in the materials used: no sight tube was used in Experiment II. In Experiment II, the localizing responses by both head and arm were made with a swinging movement of the localizing organ; results were obtained for outward swings and for inward swings. In both

experiments the body faced the front, or center of the apparatus, at all times. Differences in variability and differences of mean errors were both taken into consideration in the statistical analysis of the data.

The following factors were found to influence localizing responses in these experiments: the part of the body making the localizing response (whether it was head or arm), the position of the head in relation to body position, swinging movement of head or arm in making a localizing response, and direction of swing. The errors of localization were smaller and less variable when the subject looked straight ahead of his body than when he had his head turned away from the front of his body. When the head or arm swung in making localizing responses, the tendency was to not move far enough with the localizing organ; this was true for either head or arm as the localizing organ, and for either swinging in or out.