

ABSTRACT

AN INVESTIGATION OF TACTUAL APPARENT MOVEMENT

by Doris C. DeHardt

In previous studies concerned with apparent tactual movement, few contributions were made toward an understanding of the phenomena in question and the mechanisms responsible for their arousal; instead, the results obtained by the early workers in the area were contradictory and ambiguous. A multitude of methodological and theoretical shortcomings were seen as the bases for this state of affairs. The purpose of the present study was, by circumventing these shortcomings, to achieve such an understanding. It was believed that an adequate test of each of the following hypotheses was requisite to any complete understanding of apparent tactual movement:

- 1) Stimulus conditions which satisfy the direct relation of TI and SS, particularly at the extreme TIs and SSs, are the conditions most favorable for producing movement.
- 2) To secure maximum frequencies of apparent movement, it is not necessary that conditions in which D is inversely related to TI be used.
- 3) Frequency of on-skin movement is inversely related to TI and SS jointly, suggesting that temporal and possibly spatial summation of neural activity from the two stimuli is necessary for the experience of movement on the skin.
- 4) Frequency of off-skin movement is directly related to TI and SS jointly, indicating that "time and room" is needed to make it feasible or logical to infer movement through the air.

5) Cessation of Ss must occur (apparently before adaptation is completed) so that both S onset and S offset can be experienced in order for apparent movement phenomena to occur.

6) An awareness of the departure of the stimulating objects from the skin is necessary for the experience of off-skin movement.

Five Os, 3 males and 2 females (one of whom was not included in the data analyses since she failed to report apparent tactual movement experiences) were used in this study for one-hour periods on 14 separate days. A Bartley kinohapt was used to present one- and two-point stimulations to the volar surface of the forearm. A drum, revolving at constant speeds, upon which pawls were secured was used to achieve the desired time intervals (TIs) and durations (Ds) of Ss. The styli of the kinohapt were released by activation of the solenoids, which in turn were activated by microswitches that were tripped by the pawls. The spatial separations between Ss (SSs) were varied by moving the styli the appropriate distances apart.

A total of 101 S conditions were presented to all Os. TIs (from onset S_1 to onset S_2) ranged from 0-600 msec., Ds were 150, 300 and 5000 msec., and SSs ranged from 1.00-5.00 in. Initially, Os were instructed to verbally describe their experiences; at a later stage of the experiment, they indicated their experiences by selecting the appropriate diagrammatic representations from a key and/or by drawing additional suitable representations.

It was concluded that:

a) While the obtained relation of total amount of movement to TI and SS was only slightly in accord with the predicted relation, it was suggested that it is more fruitful and enlightening to consider, separately, the relations of on-skin and off-skin movement to TI and SS.

b) D need not be inversely related to TI in order to secure maximum frequencies of either on-skin or off-skin movement; D, in fact, is not related to occurrence of on-skin movement and probably not to off-skin movement either.

c) Frequency of on-skin movement is inversely related to TI, and completeness of on-skin movement is inversely related to SS (and to TI in minor degree). Both quantity and quality of on-skin movement are heavily dependent on the degree of pliability of the skin tissue. A conceptualization of the mechanisms involved in on-skin movement was given which accounted for the on-skin movement results obtained, and which greatly favored the notion that these mechanisms are peripheral in nature.

d) Frequency of off-skin movement is directly related to TI and SS jointly for TI sufficiently large. At small TIs, off-skin movement is infrequent, irrespective of the magnitude of SS. Thus, it was concluded that "time and room" is needed to make the inference of movement through the air feasible and that neither "time" nor "room" alone is sufficient; hence, it was concluded that off-skin movement experiences are the result of the incitement of appropriate visual images.

e) The physical cessation of Ss is not necessary for the occurrence of apparent tactual movement phenomena.

f) Experiences of on- and off-skin movements are frequently accompanied by experiences of pick-up of the stimulating objects from the skin. It is not entirely obvious why this association was true of on-skin movement as well as of off-skin movement.

It was concluded that because on-skin and off-skin movements are primarily aroused by different S conditions and were believed demonstrated to depend on different mechanisms, a complete understanding of apparent tactual movement cannot be achieved unless a distinction between the two types of movement is maintained.

Date Aug 9, 1961

AN INVESTIGATION OF TACTUAL APPARENT MOVEMENT

By

Doris C. DeHardt

A THESIS

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

DOCTOR OF PHILOSOPHY

Department of Psychology

1961

G 20892
5/24/66

ACKNOWLEDGMENTS

I am greatly indebted to Professor S. Howard Bartley for the guidance and inspiration he has given me, not only during the course of this investigation but throughout all of my advanced graduate training. I am grateful and proud of having been associated with him. I also wish to thank Drs. Donald M. Johnson, Paul Bakan, and James H. Stapleton for their assistance in this investigation.

To Mrs. Ardys Cox, Mr. Alfred Crowell, Dr. Thomas M. Nelson, Miss Jane Ranney, and Mr. Thomas Trabasso, who contributed many hours of their time as observers, I especially wish to acknowledge my gratitude.

TABLE OF CONTENTS

CHAPTER	Page
I. HISTORICAL REVIEW	1
II. STATEMENT OF THE PROBLEM	16
III. METHOD	20
Observers	20
Apparatus	20
Procedure	25
IV. RESULTS	33
1. Relation of TI to SS	34
2. Relation of TI to D	36
3. On-skin movement as a function of TI and SS .	36
4. Off-skin movement as a function of TI and SS .	39
5. Apparent movement in the absence of S offset: d = 5000 msec. conditions	45
6. Experience of pickup of stimulating objects . .	47
One-point stimulations	48
Verbal responses	48
Results of conditions in which TI = onset S_1 to onset S_2 interval.	49
V. DISCUSSION	55
Hypothesis 1	55
Hypothesis 2	56
Hypothesis 3	57
Hypothesis 4	60
Hypothesis 5	61
Hypothesis 6	62
VI. SUMMARY AND CONCLUSIONS	70
REFERENCES	74
APPENDICES	77

LIST OF TABLES

TABLE	Page
1. Proportion of On-skin, Off-skin and Total Movement Responses at $D = 150, 300,$ and 5000 msec.	35
2. Relative Frequencies of the Three Types of On-skin Movement at $SS = 1.00$ to 4.00 in.	40
3. Relative Frequencies of the Three Types of On-skin Movement at TI (offset S_1 to onset S_2) = -150 to 300 msec.	40
4. Perceived Nature of the Departure of the Stimulating Object for One-point Ss of $D = 150, 300,$ and 5000 msec.	48

LIST OF FIGURES

FIGURE	Page
1. A Bartley Kinohapt	21
2. Theoretical Proportion of Movement as a Function of TI for SS = 1.00, 2.00, 3.00, and 4.00 in.	37
3. Obtained Proportion of Movement as a Function of TI for SS = 1.00, 2.00, 3.00, and 4.00 in. at D = 150 and 300 msec.	37
4. Obtained Proportion of Movement as a Function of TI for all SSs Combined at D = 150 and 300 msec. Con- ditions.	37
5. Theoretical Proportion of On-skin Movement as a Func- tion of TI for SS = 1.00, 2.00, 3.00, and 4.00 in. . . .	38
6. Obtained Proportion of On-skin Movement as a Function of TI for SS = 1.00, 2.00, 3.00, and 4.00 in. at D = 150 and 300 msec. Conditions.	38
7. Theoretical Proportion of Off-skin Movement as a Func- tion of TI for SS = 1.00, 2.00, 3.00, and 4.00 in. . . .	41
8. Obtained Proportion of Off-skin Movement as a Function of TI for SS = 1.00, 2.00, 3.00, and 4.00 in. at D = 150 and 300 msec. Conditions.	41
9. Proportion of Total, On- and Off-skin Movement for All <u>Os</u> at D = 150 msec. as a Function of TI.	43
10. Proportion of Total Movement for Each <u>O</u> at D = 150 msec. as a Function of TI.	43
11. Proportion of On- skin Movement for Each <u>O</u> at D = 150 msec. as a Function of TI.	43
12. Proportion of Off-skin Movement for Each <u>O</u> at D = 150 msec. as a Function of TI.	43

LIST OF FIGURES - Continued

FIGURE	Page
13. Proportion of Total, On- and Off-skin Movement for All <u>Os</u> at D = 300 msec. as a Function of TI.	44
14. Proportion of Total Movement for Each <u>O</u> at D = 300 msec. as a Function of TI	44
15. Proportion of On-skin Movement for Each <u>O</u> at D = 300 msec. as a Function of TI	44
16. Proportion of Off-skin Movement for Each <u>O</u> at D = 300 msec. as a Function of TI	44
17. Proportion of Movement that is On-skin Movement as a Function of TI for D = 150 and 300 msec. Conditions . .	46
18. Proportion of On- and Off-skin Movement at D = 150 and 300 msec. as a Function of SS	46
19. Proportion of On-skin Movement for Each <u>O</u> at D = 5000 msec. as a Function of TI	46
20. Proportion of Off-skin Movement for Each <u>O</u> at D = 5000 msec. as a Function of TI	46
21. Proportion of On-skin Movement as a Function of TI for D = 150, 300, and 5000 msec. Conditions	50
22. Proportion of Off-skin Movement as a Function of TI for D = 150, 300, and 5000 msec. Conditions	50
23. Proportion of On-skin Movement as a Function of TI for Individual <u>Os</u> at D = 150 msec.	50
24. Proportion of Off-skin Movement as a Function of TI for Individual <u>Os</u> at D = 150 msec.	50
25. Proportion of On-skin Movement as a Function of TI for Individual <u>Os</u> at D = 300 msec.	51
26. Proportion of Off-skin Movement as a Function of TI for Individual <u>Os</u> at D = 300 msec.	51

LIST OF FIGURES - Continued

FIGURE	Page
27. Proportion of On-skin Movement as a Function of TI for Individual <u>Q</u> s at D = 5000 msec.	51
28. Proportion of Off-skin Movement as a Function of TI for Individual <u>Q</u> s at D = 5000 msec.	51
29. Proportion of On- and Off-skin Movement as a Function of SS for All <u>Q</u> s at All Supplementary S Conditions. . . .	54
30. Proportion of On-skin Movement and Bouncing for Each <u>Q</u> at D = 150 msec. as a Function of TI.	54
31. Proportion of On-skin Movement and Bouncing for Each <u>Q</u> at D = 300 msec. as a Function of TI.	54
32. Proportion of On-skin Movement and Bouncing for Each <u>Q</u> at D = 5000 msec. as a Function of TI	54

LIST OF APPENDICES

APPENDIX	Page
A. Response Key	78
B. Data Sheet	79

CHAPTER I

HISTORICAL REVIEW

Although apparent movement was of interest to researchers as early as 1833 (Stampfer), it was Wertheimer, in his classic paper of 1912, who gave impetus to the considerable concern for apparent movement which resulted in the enormous number of investigations of the phenomenon in this century, at first of visual apparent movement and then subsequently of auditory and tactual apparent movement. In his paper, Wertheimer asserted that the apparent movement in vision is a unique experience composed of unanalyzable "pure movement," wherein no object is perceived and even the attribute of quality is absent. The pure movement was called the "phi-phenomenon," and to account for it, Wertheimer suggested a physiological explanation in terms of Kurzschluss, or "short-circuits," occurring within the visual cortex. The school of Gestalt psychology credits its origin to Wertheimer's experiment; its proponents accepted the phi-phenomenon as an outstanding illustration of the non-additive configurations with which they were concerned.

Korte (1915), in confirming Wertheimer's description and explanation, presented laws or conditions (relating to the stimuli which arouse the phi) necessary for the optimal occurrence of apparent movement. The primary laws are: 1) spatial separation and temporal interval are directly related; 2) spatial separation varies directly with intensity; 3) intensity varies inversely with temporal interval; 4) duration is inversely related to temporal interval.

Many researchers attempted to verify Wertheimer's description and explanation and Korte's laws for visual apparent movement. Among the

early workers were Benussi, 1917; Dimmick, 1920; Hillebrand, 1922; and Higginson, 1926. Others (Burt, 1917; Scholz, 1925; Mathieson, 1932) attempted to determine whether the experience of phi could be produced with the auditory modality, and if so, was auditory phi subject to Korte's laws. Still other experimenters studied tactual apparent movement. It is to those papers concerned with tactual apparent movement that detailed consideration will now be given. As in the studies of visual and auditory apparent movement, researchers in tactual apparent movement generally attempted to determine: A) whether pure movement could be obtained, B) whether there existed compulsory (mandatory) stimulus conditions for the arousal of apparent movement, C) what the possible limiting range of stimulus values capable of its arousal was, D) whether there existed similarities of tactual apparent movement to visual and auditory, E) whether Korte's laws were valid, and F) what the existential correlates of apparent movement were.

Casual mention of the experience of tactual apparent movement was made by Judd in 1896. Using successive two-point stimulations with knitting needles, he found that when the second point was presented before the cessation of the first "with the application of the second stimulus there was sometimes simply an increase of pressure accompanied by a blunting or diffusion of the sensation" (p. 428). Von Frey and Metzger (1902), in attempting to determine what time interval(s) minimize the difference thresholds for two-point successive stimulations, obtained from their Os, descriptions of a "shifting" or "stroking" of the stimulus along the skin.

Benussi (1913) made the first direct study of tactual apparent movement, using a device which he built, called the Benussi kinohapt, for the purpose of presenting successive two-point stimulations of varying intensities (I), time intervals (TI), spatial separations (SS), and durations (D) to the skin. The essential characteristics of the device were that tiny rubber tips were mounted on stiff wires which were fitted to brass rods

and suspended vertically. The wires were activated by solenoids in such a way that when the circuit was completed through the coil of the solenoid, the rod was expelled downward carrying with it the rubber-tipped wires (the stimulating objects) which fell of their own weight upon the skin. When the circuit was re-made the rod, and with it the stimulus objects, retracted from the skin.

In his paper of 1913, Benussi reported obtaining tactual apparent movement, and in his paper some of the descriptions of movement given by his Os are quoted. However, Benussi made little attempt to answer the various questions posed regarding movement phenomena. Nevertheless, in a study reported in 1917, he did so.

Using his kinohapt to present conditions with time intervals (from onset S_1 to onset S_2) ranging from 0-2200 msec., spatial separations from 3-170 cm., and durations of various fractional multiples of his TIs (which he did not report) Benussi reported that with $TI = 90-120$ msec. and $SS = 2-20$ cm. fluttery "shiftings" within each of the successive areas were aroused; with $TI = 240-260$ msec. and $SS = 3-12$ cm., "stroking" movements were aroused between the first and second pressure spots; with $TI = 360-620$ msec. and $SS = 3-20$ cm.; "bow" movements, the experience of something leaping through the air, were aroused. Benussi reported that he suspected attitudinal factors were important in the perception of tactual apparent movement because he found that immediately after movement had been aroused at a given TI and SS, it could be aroused again with the same TI for different SSs. He also found an optimal constant ratio of 1:4 between TI and D. And although he stated that even the most definite movements were of the most impalpable sort, he felt that pure movement was not experienced. Tactual apparent movement was, to Benussi, dependent upon a temporal judgment of a supra-sensory order determined by processes of memory.

Burt (1917) investigated tactual illusions of movement with the avowed purpose of verifying Korte's laws. In attempting to establish whether duration is inversely related to time interval, conditions of $D = 21, 42, 63, 84, 105$ and 126 msec. and TI (from onset S_1 to onset S_2) = $15, 21$ and 40 msec. were presented to 4 Os. (All possible combinations of D with TI were used in the experiment, but not all Os received all conditions.) Spatial separation was held constant at 12 cm. Two Os showed a direct relation and two an inverse relation between D and TI , certainly not evidence in support of Korte's law.

Burt did claim evidence for a direct relation between SS and TI . To put this law to test, he used time intervals (from onset to onset) of $15, 30, 45, 60, 75$ and 105 msec. and spatial separations of $8, 12$ and 16 cm. keeping D constant at 60 msec. Upon examination of the data presented by Burt in tabled form (p. 379), however, several deviations from the purported relation can be noted, e.g., movement occurred at $SS = 16$ cm., $TI = 60$ msec. It appears that Burt was a bit optimistic about the conclusiveness of his results. There was a general increase in movement as TI increases up to 75 msec., and a decrease thereafter, i.e. at 105 msec.

The short-circuit theory was rejected by Burt who suggested, instead, that there may be a continuity of motor adjustment (e.g. with the head and eyes) from S_1 to S_2 which gives the illusion of movement.

Whitchurch (1921) classified movement experiences into five types, the first researcher in the area to attempt a classification. The five types were: 1) full movement, in which the stimulus seemed to move from the first to the second spot stimulated; 2) bimembral movement, in which the first and second stimuli each seemed to move; 3) unimembral movement, in which either the first or second stimulus seemed to move; 4) intramembral movement, in which the stimulus at one or both spots seemed to move within the area of stimulation; and 5) pure phi, in which

the apparent movement had no qualitative, intensive or extensive beginning and ending, but was a uniform "brushing" over the cutaneous surface.

In her principal experiment, using 4 Os, Whitchurch used $D = 150$ msec., TI (from onset S_1 to onset S_2) = 25, 50, 75, 100, 250, 500, 750 and 1000 msec. and $SS = 2.1-5.5$ mm. conditions. Not all Os received all S combinations. The maximal amount of full movement was reported at $TI = 150$ msec. The frequency of all types of movement increased up to 50 msec., remained nearly constant until $TI = 250$ msec., and decreased continually after 100 msec. It is well to note here that Whitchurch was concerned only with cutaneous or "on-skin" movement and not "off-skin" or bow movement. She restricted herself to tiny spatial separations so as to avoid visual association, which is necessary for the experience of bow movement.

To two of her 4 Os, Whitchurch presented a few conditions of $D = 75$ and 200 msec. Incidence of full movement was less for these durations than for 150 msec. duration conditions. She did not report amount of other types of movement at these durations.

Whitchurch theorized very little in her paper, but she stated that a higher perceptual order is involved in tactual apparent movement than in visual apparent movement, so that there is less probability of determining compulsory conditions for the tactual. Some of her Os reported that they experienced pure ϕ .

Andrews (1922) attempted to obtain optimal conditions for bow movement. He presented conditions of $D = 150$ msec., TI (from onset S_1 to onset S_2) = 100-1600 msec. and $SS = 2, 6, \text{ and } 10$ cm. He presented no data in quantified form (only some typical introspective reports were given), but Andrews stated that no quantitative relations could be established. He, like Benussi, suggested the importance of the proper subjective attitude. One trained O reported apparent movement on 45% of the presentations. Two untrained Os reported none until the phenomena were indirectly suggested

by rapidly repeating the conditions in close succession. Andrews concluded that the perception of movement in or on the skin is inferred from a spatial and temporal integration of pressure, and that this perception is of a type different from the subjective processes which carry the meaning of bow movement through the medium of associated visual and kinesthetic images.

In a study primarily concerned with comparing the phenomenal extent, i. e., the perceived length, of apparent movement in vision, audition and touch, Scholz (1925) reported no strict regularity in the relations governing optimal movement, and his results contradicted Korte's space-time law (in contrast to Burt's purported verification of it). He presented conditions with TI (from offset S_1 to onset S_2) = -150 to 900 msec., SS = 2 to 16 cm., and D = 150 msec. Scholz explained apparent movement by the Hartmann-Köhler modification of Wertheimer's theory.

The purpose of a major investigation by Hulin (1927) was ". . . to determine the possibility of compulsory conditions for the arousal of tactual apparent movement by a succession of temporally and spatially discrete stimuli. The limiting range of values was sought which would arouse tactual movement" (p. 293). He used a modified form of Benussi's kinohapt to present stimuli which were always of duration 150 msec., were spaced temporally (from offset S_1 to onset S_2) from -150 to 300 msec. and spatially from 5 to 150 mm. Not all Os received all stimulus combinations. The Os were asked to draw a graphic representation of each cutaneous perception aroused. The possible impressions were characterized by Hulin as being of three classes, simultaneous, successive, and movement. Diagrams of various types of experiences within each of these three classes were given to Os, and were to be used by them as a key or guide for their graphical reporting. That is, Os were told to draw their characterizations as nearly as possible according to the symbols shown in the key; however, if they found the key inadequate, they were to draw

any additional suitable diagrams. A few of the diagrams used in the present study were those used by Hulin (see Appendix A, diagrams A1, A2, A5, B1, B5, C1, C2, C3, C8, C12).

Hulin sub-divided movement into three different types in his diagrams. These were a) full, identical with Whitchurch's full movement, b) end, combined Whitchurch's bimembral and unimembral movement, and c) bow, defined as Benussi defined it, i.e. a sort of leaping through the air. An additional type of movement was added by some of Hulin's Os and was the type that Whitchurch called intramembral movement. Hulin called it inner movement.

Like Whitchurch, Hulin was interested primarily in the conditions producing full movement. He found the maximum amount of it at $TI = -75$. For $D = 150$ msec. which Hulin always used, this is, then, equivalent to a 50% temporal overlap for the two Ss which corresponds to an interval of +75 msec when TI is measured from onset to onset. Further, he reported a steadily decreasing frequency of full movement at successively longer TIs. Precisely the same results were obtained for all types of movement combined. There was little difference in frequency of movement as a function of spatial separation except for that of 150 mm., where little movement occurred. The highest frequency of movement was obtained for conditions of $SS = 70$ mm. Therefore, Korte's suggested direct variation of time and space was not verified. In fact, Hulin felt that the only quantitative relation shown by his data was that the time interval of -75 msec. ". . . is exceptionally favorable for the arousal of apparent tactual movement" (p. 320).

By way of theorizing, Hulin stated that ". . . the apparent tactual movement consists of a perceptual complex which involves at least four persistent though variable factors; the peripheral factors of (i) pressure irradiation and (ii) perseveration, and the subjective (associative) factors of (iii) visual imagery and (iv) kinaesthesia" (p. 320).

Neuhaus (1932) used a modified Benussi kinohapt to present two-point stimulations of various time intervals, spatial separations, and durations. He obtained illusory movement for time intervals ranging from 0 to 500 msec. His results suggested verification of Korte's space-time relation. And he found that when distance and time were held constant, movement was most likely to occur at either long or short stimulus durations. Some Os failed at all times to report apparent movement. Neuhaus was also concerned with the speed and direction of apparent movement, but since the present paper is not directly concerned with these matters, discussion of them will be foregone.

Neuhaus rejected physiological theories of apparent movement phenomena and said instead that, "Apparent movements are of a psychological nature" (p. 551). Two of the several arguments he gave for this view were: 1) the occurrence of apparent movement is dependent upon will, set and attention, so it cannot be physiologically determined, and 2) stimulus conditions are, in themselves, inadequate to explain the phenomena. Kelly (1935) subsequently, and Benussi (1917), and Andrews (1922) previously reported evidence to support the first argument. However, because the statement in 2) is true of the present state of affairs, it does not necessarily follow that physiological mechanisms cannot account for apparent movement. Perhaps, by a new experiment, the state of affairs will be reversed.

Neuhaus' was the last serious attempt to answer the questions posed by the early workers in apparent tactual movement. Since his report appeared, a few studies bearing only slightly on these questions have been reported. Schaeffer (1939) presented diffuse stimulations to various areas of his Os skin by means of a shower bath of moderate pressure, using a shower head with varying numbers of holes. Apparent movements were reported and were described as spirals and linear to-and-fro surges. Individual differences were marked. In most cases, movement of the body

changed the direction of the apparent movement, and voluntary acts, loss of sleep, and treatment of the skin with ultra-violet light modified the spirals and surges. Schnehage (1939) used nearly simultaneous, rhythmical, alternating Ss to ascertain whether blind Os experience tactual apparent movement on various parts of the body as do normally-sighted Os. He reported that they did.

Several studies and theoretical papers, in addition to those already mentioned, dealt with and discussed the importance of attitude, set, learning, and motivation in the determination of apparent movement (Pieron, 1934; Ryans, 1937; Lehmann, 1939; Jones and Bruner, 1954; Toch and Ittelson, 1957). All of these authors believed that, because of the influence on movement phenomena which these subjective factors were shown to have, Gestalt theory attempting to account for movement was heavily discredited.

In all of the studies of apparent tactual movement heretofore, it has been assumed that the effective stimulus for pressure sensations is simply contact upon the skin by an object with supra-threshold force. If one held the skin depressed at a constant level for a period of time, it was usual to assume that such constituted a continuance of stimulation or a constant stimulus, and it was assumed that the release or removal of that object making the depression was cessation of stimulation. Nafe and Wagoner (1941a, 1941b) (and others less significantly) have since shown that such a conceptualization of the adequate stimulus for the tactual modality is not entirely accurate. Nafe and Wagoner found that it was not the deformation of the skin, per se, but rather the process of deformation which is necessary for stimulation. More specifically, it is the process of deformation occurring at or above a critical rate which constitutes stimulation. They concluded thusly:

The present experiment indicates that any force exerted against the pliable tissues sensitive to pressure will be effective as a stimulus as long as it sets up movement of the innervated tissue

above a minimum in amount and rate. . . . If stimulation is produced by releasing a pressure from the tissues instead of by applying it, the same result, i.e. a movement of the tissue, is obtained due to the elasticity of the tissues and the effect for sensation is the same. (1941b, p. 349)

(They found that a sensation was usually reported upon the release of the pressure, but not always. The fact that some of their kymographic records of the rate and amount of deformation and re-formation showed that recovery (re-formation) was not immediately completed, i.e. the amount of movement in re-formation was less than in deformation, would account for this. It was reported that amount of recovery depended on magnitude and duration of pressure.)

This new conceptualization of what constitutes an adequate tactual stimulus has great significance for studies of apparent tactual movement, or any tactual study for that matter. In all of the previous studies (except Schaeffer's), two-point stimulations were used. But since an object can stimulate when it deforms and when it reforms, it is possible that, in actuality, four stimuli were unwittingly being presented. And if the stimulating objects failed to move the skin at or above the critical for any length of time while they made contact with the skin, then the actual durations of the stimuli were not what they were purported to have been. The nature of the stimulus for touch as we now know it, must surely be taken into account, then, if any real understanding of apparent tactual movement is to be realized.

From the historical review, it is clear that the questions set forth for examination in the several studies were by no means unequivocally answered. Indeed, it is difficult to make any statement regarding the status of tactual apparent movement other than that it is highly ambiguous. The fact that so little can be made of the results of the previous studies is undoubtedly due, in part, to the procedural dissimilarities, i.e. dissimilarities of apparatus, observers or Os, stimulus conditions, and

treatment of results, in part to the inadequacies of same, and in part to the fact that the questions were generally misstated, i. e. stated in such a way that they were unanswerable.

It is probably always the case that procedural dissimilarities among studies contribute to dissimilar results. It seems certain that this was true of the apparent tactual movement studies, in which dissimilarities were the rule rather than the exception. Some of the relevant differences were:

- a) hairs, blunt rubber-tipped rods, and pointed rods or needles were used as stimulus objects,
- b) Os were sometimes naive, sometimes highly sophisticated, particularly in those studies in which E also served as an O,
- c) some researchers marked the skin (the forearm was always used, if not other areas in addition), and stimulated only the marked areas, but most did not,
- d) Burtt removed hair from Os' arms, but no others reported having done this,
- e) random orders were used wholly or partially by some workers, and not at all by others,
- f) several different types of movement were defined and occasionally at least a few of these were treated separately by some investigators, while others were concerned only with incidence of movement in general.
- g) only in the study by Burtt (1917) was mention made of dampening (or attempting to dampen) auditory stimuli from the timing devices, and only Burtt and Hulin shielded the apparatus from Os view, or at least only they mentioned having done so,
- h) the Os in some studies served several hours a day, in others only one hour per day (Whitchurch did not even mention the length of her experimental sessions or how many there may have been in a single day),

- i) in some studies Os received all possible S combinations and in others they did not,
- j) treatment of results varied widely from paper to paper,
- k) the conditions themselves varied considerably as to time interval, duration, spatial separation, and undoubtedly intensity, also, although rarely was the intensity of S mentioned.

Methodological differences thus were legion; it is not surprising that some procedures were less adequate than others. The inadequacies of certain of the procedures and some shortcomings common to all the studies will now be indicated.

In the studies which made use of Os who knew the purpose of the experiment in which he participated, and this was true of most studies using sophisticated Os, results could have been biased owing to the highly suggestible nature of apparent tactual movement phenomena. It was found by this writer (in preliminary experimentation), and in all likelihood by others also, that a practiced O is required in an experiment involving tactual apparent movement in order to obtain reliable reports (probably because movement experiences are often hazy, transitory and strangely unreal). However, the practiced O does not imply the knowledgeable O. It seems to me that Os would best be treated by telling none of them the purpose of the experiment, giving them all the same amount of practice on the same conditions prior to the experimental conditions, and by establishing and defining certain response categories (similar to Hulin's technique, for example) for them so that all Os will use identical criteria for the classification of their responses, thus making it possible justifiably compare and combine Os' reports. This was rarely possible in previous studies. And while it is true that the nature of the experiment is suggested to O by giving him a number of diagrams by which he is to categorize his responses, the purpose, nevertheless, remains obscured.

Since Benussi (1917) suggested that having gotten movement on a preceding condition can alter the probability of obtaining movement on a succeeding condition, it goes without saying that randomization of conditions is essential.

Failing to stipulate criteria which differentiate the several types of apparent movement as did some of the early workers, in addition to the aforementioned shortcoming, also had the disadvantage that it served to lessen the likelihood of achieving an understanding of movement phenomena. All types of movement were combined into single frequency distributions, obviating the possibility of establishing that different stimulus conditions account for different types of movements. This seems particularly true of on-skin versus off-skin movement. These are very different experiences. Could not different conditions have given rise to them? Recall that Benussi (1917) found on-skin movement at relatively short time intervals, off-skin movement at relatively long time intervals. And Andrews (1922) suggested that these two major types of movement were the result of different processes. Do not the S conditions presented at a particular time determine which processes are involved at that given time?

In experimentation preliminary to the present study, I found that being able to hear the timing devices which determine the release of the stimulating objects to the skin (in this case microswitches), altered the amount of movement experienced. For conditions of relatively short time intervals, the probability of movement was increased, apparently because the "clicks" from the two microswitches had a rhythmical quality which was interpreted tactually as a smooth, rolling motion. For relatively longer time intervals, the clicks seemed to enhance the discreteness of the two tactual stimulations, because the amount of movement was lessened. It was also found that being able to see the needles drop onto the arm decreased the likelihood of experiencing movement. In other words, when relevant auditory and visual stimuli accompany the tactual stimuli,

curiously biased reports of apparent movement can result, so it is essential to eliminate such auditory and visual stimuli.

Presenting up to 500 trials per day as did Burtt, leads one to wonder whether fatigue and boredom might not have influenced the results obtained. It seems ill-advised to have more than one or two hours a day of experimental participation so as to avoid such complications. And intertrial intervals were uniformly not reported. If they were very short, fatigue again might have been a complicating factor.

Part of the failure to answer the questions posed in these studies was due to the generally inadequate treatment of results. In the papers in which only sample introspections were reported, it is not possible to express quantitative relations between and among stimulus conditions. Most often, the raw data in the form of key words describing the experiences, e. g. series, flow, snake effect, were presented. But even in these cases it is difficult to determine just exactly what types of movement were experienced, because what connotations the key words had to the user(s) is not always obvious. Hulin presented his results in graphical form, but since not all Os got all conditions, the value of such a treatment for inferential purposes is questionable. Because the results from every previous study indicate that the absolute amount of movement varies considerably between Os, failing to give all Os all conditions in an experiment renders it impossible to make meaningful frequency distributions of movement (as a function of time interval, for example), either for individuals or for the group.

None of the previous researchers reported the degree to which their timing devices were accurate. Although there is no particular reason to be suspicious, it should be pointed out that unless extreme care were taken to achieve and maintain accurate timing, the time intervals and durations may have been in error (i. e., not what they were purported to have been). It is impossible to tell whether such care was taken and simply not reported, or whether it was absent altogether in these studies.

At any rate, conditions whose temporal characteristics are of the order of milliseconds are very precisely timed conditions, indeed.

The early workers surely would have obtained more fruitful and conclusive evidence in support of their views if they had asked questions which were more amenable to experimental examination. The question, what are the existential correlates of apparent movement, while of a sort common to the introspectionist of the early 20th century, seems meaningless to us now. And how can one be sure he has or has not experienced pure phi? There seems to have been some doubt about just how unreal it is; conclusions as to whether phi occurred or not seem to have depended on the judgments of the experimenters.

It was particularly unfortunate that the early researchers sought compulsory conditions for the arousal of apparent movement. Very few psychological antecedent events result in totally certain outcomes, in fact, not a single example of such comes to mind. One must be content in psychological research to seek out conditions which have higher or lower response probabilities than other conditions.

CHAPTER II

STATEMENT OF THE PROBLEM

Inasmuch as the previous studies were fraught with these several methodological and theoretical difficulties, it is not surprising that few positive contributions regarding apparent tactual movement were made. If one were to execute a methodologically sound experiment, however, a number of questions, meaningfully stated and worthy of being entertained, could be put to test. Such is the purpose of the present investigation. It is hoped that as a result, our knowledge and understanding of apparent tactual movement specifically, and the tactual modality in general, will consequently be enhanced. The questions are the following:

1) Can stimulus conditions be identified which have high probabilities of producing apparent tactual movement? Are stimulus conditions which satisfy Korte's specifications those which have high movement response probabilities? And what conditions, if any, are not likely to be associated with reports of movement?

2) Do movements on-skin and movements off-skin tend to occur under different types of stimulation? What are the stimulus conditions associated with the two classifications of movement?

3) Assuming 1), is it possible to infer what are the physiological and psychological mechanisms of apparent tactual movement? And assuming 2), can one infer that different mechanisms are operating for on- and off-skin movement? In other words, are there characteristics of the high response-probability stimulus conditions which suggest the operation of certain mechanisms as opposed to others?

4) Is the offset of S, which we now know is not cessation but continuation of S or restimulation, necessary for apparent movement? Is it necessary for on- and off-skin movement, or just for one and not the other?

5) Is the experience of pickup, i. e. the awareness of the withdrawal of the stimulating objects, necessary for apparent tactual movement, both of the on- and off-skin variety, or is it necessary only for off-skin (or on-skin) movement?

To ascertain more definitely the ranges the several S variables require, a pilot study was conducted prior to the present investigation. All possible combinations of TI (from offset S_1 to onset S_2) = -150, -75, 0, 75, 150, and 300 msec.; D = 75, 150, 300 and 5000 msec. (the latter meaning no offset prior to adaptation); and SS = 1.25, 2.50, 3.75, and 4.50 in. were presented to one O in semi-randomized order in one-hour sessions. An average of 10 conditions were presented per session, with one session per day. O was asked to describe or relate everything he experienced. (See p. 25 of the Procedure for details; the procedure in the pilot study was similar to that of the present study.) O's reports suggested the following:

a) There are conditions which have much higher response probabilities than others. Specifically, A) the shorter the time interval, particularly for short spatial separations, the greater the frequency of movement, and B) the longer the temporal and spatial intervals, the greater the frequency of movement. Thus, Korte's space-time relation seemed valid.

b) The movement which was reported with type A conditions was almost entirely on-skin movement, and many of the movement responses to type B conditions were of the off-skin variety.

c) Movement occurred with approximately 50% of the conditions of D = 75, 150 and 300 msec. The maximal amount of movement for D = 75 occurred at TI = 0 and 75, for D = 150 at TI = 150 and for D = 300 at TI = -150, suggesting that optimal movement is not necessarily obtained for conditions where D is inversely related to TI.

d) The results in b) seem to suggest that on-skin movement may depend for its existence on neural temporal and, possibly, spatial summation, and that the visual imagery associated with off-skin movement is enhanced by "spreading out" the two stimuli in space and time. It would seem likely, though, that if the temporal and/or spatial intervals were increased to a sufficient extreme, reports of movement would cease.

e) No movement was reported for conditions of $D = 5000$ msec. O reported very infrequently that he experienced pickup; however, in these cases he stated that since pickup occurred after he no longer felt the objects on his skin (i. e. adaptation had taken place), it seemed to him as though pickup were just another S presentation.

f) O was not asked to report whether he was aware of pickup on any conditions except those of $D = 5000$ msec. However, it is believed that an awareness or experience of pickup is necessary for off-skin movement. That is, perhaps movement through the air is experienced because the pickup is experienced (particularly of S_1) and one simply infers that the first S continues through the air and strikes again. (This supposition was borne out by some of O's verbal descriptions. For example, he reported an experience which was like "a bird sailing through the air which touched down with its feet in two places.")

From the results of the pilot study and to a lesser extent from the previously reported studies, the following hypotheses, which are the experimental hypotheses of this study, are suggested:

1) Stimulus conditions which satisfy the direct relation of TI and SS, particularly at the extreme TIs and SSs, are the conditions most favorable for producing movement.

2) To secure maximum frequencies of apparent movement, it is not necessary that conditions in which D is inversely related to TI be used.

3) Frequency of on-skin movement is inversely related to TI and SS jointly, suggesting that temporal and possibly spatial summation of neural activity from the two stimuli is necessary for the experience of movement on the skin.

4) Frequency of off-skin movement is directly related to TI and SS jointly, indicating that "time and room" is needed to make it feasible or logical to obtain movement through the air.

5) Cessation of Ss must occur (apparently before adaptation is completed) so that both S onset and S offset can be experienced in order for apparent movement phenomena to occur.

6) An awareness of the departure of the stimulating objects from the skin is necessary for the experience of off-skin movement.

CHAPTER III

METHOD

Observers. -- Five Os, 3 males and 2 females, ranging in age from 22-37 years were used. Three were psychology graduate students, one a research associate in psychology and one an undergraduate senior psychology major. Since all Os were psychologists or aspiring psychologists, they were sufficiently sophisticated psychologically to be able to ascertain the nature of the experiment. All of them knew that the experiment in some way dealt with tactual experiences and that primary among those of interest were movement experiences. However, none of them was aware of the specific questions with which the study was concerned. Each O was asked at the end of his final participation period to state what he thought the experimental hypotheses of the study were. None gave even a fair approximation of any of the hypotheses.

Apparatus. -- A Bartley kinohapt (see Fig. 1) was used to present the stimuli to the volar surface of the forearm. Although, as can be seen in Fig. 1, the kinohapt can be used to present three stimuli, in this experiment either one or two only were presented on any given trial. The styli in this experiment were size 14 Singer sewing machine needles. Horizontal and vertical adjustments of the solenoids were made with knobs 3 and 4 as shown in Fig. 1. The left- and middle-positioned styli were always used in this experiment. It was possible to separate these styli vertically by distances ranging from $3/4$ to $5\ 1/4$ in. The solenoids were activated by microswitches and were wired in parallel. The microswitches

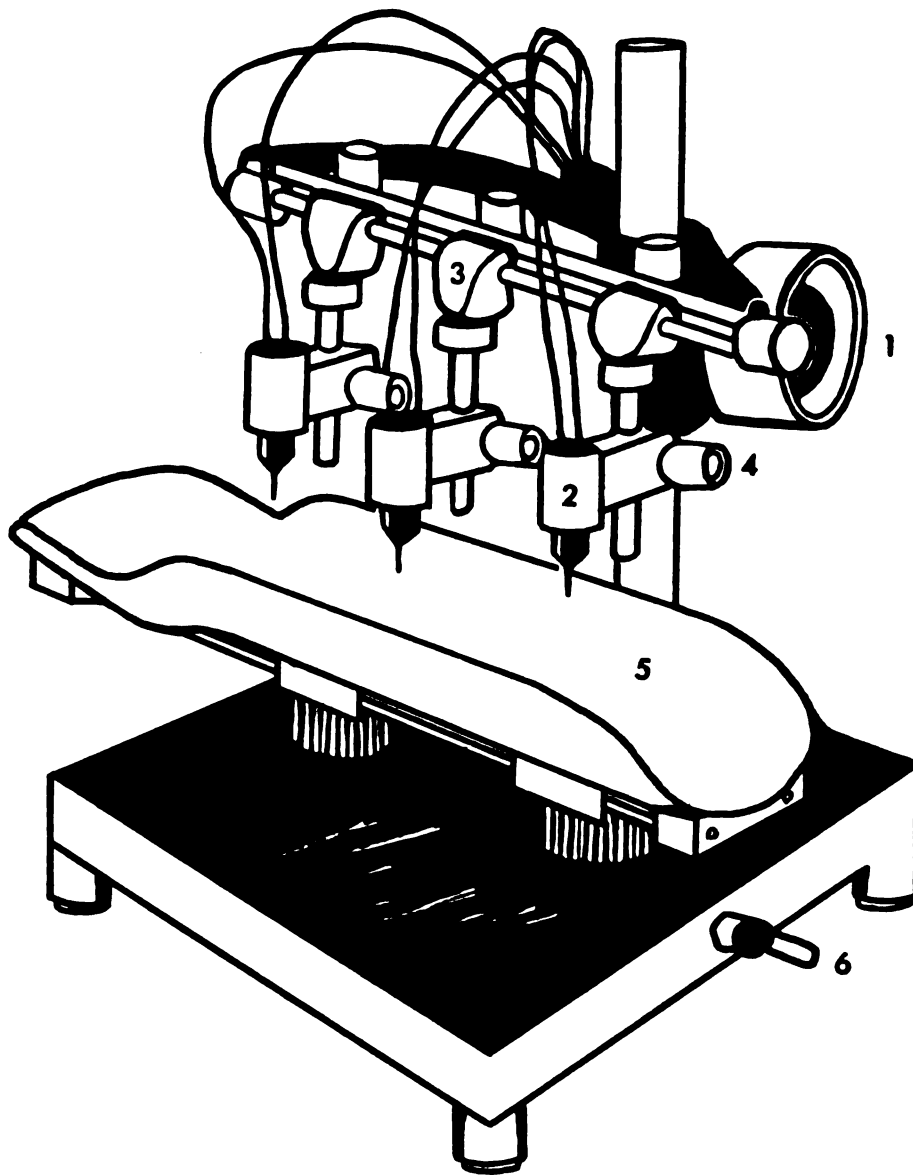


Fig. 1. A Bartley Kinohapt. Item 1 is the knob for adjusting the whole carriage vertically; 2 is one of the solenoids activating a stylus; 3 is a solenoid carriage adjustable horizontally; 4 is a knob adjusting a single solenoid vertically; 5, the arm rest, adjustable in all directions; 6, the arm-rest lock. (From Principles of Perception, Fig. 17.4, by permission of S. Howard Bartley.)

were tripped by pawls on a revolving metal drum. Tripping the switches opened the circuit, releasing the styli to fall of their own weight ($S_1 = .365$ gr., $S_2 = .340$ gr.) to the skin. (The time lag from circuit opened to the complete fall of a stylus was no more than 13.5 msec., and likewise, for the lag from circuit closed to complete retraction. This was established by determining the maximal number of full falls and retractions which could occur in a given length of time. It was found that a single release and retraction, for each stylus, required approximately 27 msec. Assuming that the time of release and of retraction are identical, which seems plausible, but was not definitely established [It looked as though the two processes took place with similar speeds, but at these speeds, the visual system is not sufficiently acute.], then each process required about 13.5 msec. If the processes were completed in identical times, then the lags were of no significance; the stimuli simply occurred the length of the lag later in time than supposed. The actual lag from circuit opened to contact of stylus upon the skin, and from circuit closed to withdrawal from the skin, was somewhat less than 13.5 msec., because both styli were adjusted on every trial so as to be only $1/4$ in. from the skin [in the retracted position, of course]. The distance of the full fall of the styli, however, was $3/4$ in.).

The microswitches were mounted on posts carried by a ring concentric with the bottom edge of the drum. Their heights could be adjusted so as to have the microswitches activated by the necessary pawls required for duration variations. The posts, and consequently the microswitches, could be moved horizontally around the ring by loosening the clamps which secured them. The positions of the two microswitches could thus be varied so as to provide a wide range of time intervals between S_s .

Stimulus durations of 150, 300 and 5000 msec. were chosen for use in this study. For conditions consisting of two stimuli, S_1 and S_2 , the duration of S_1 always equalled almost that of S_2 , since the weights of the

styli were almost equal and were never varied in this experiment. To present stimuli which would make contact with the arm for these lengths of time, the following scheme was used: the aforementioned drum, which had a circumference of 18.06 in., was driven by a Cenco Stirrer (variable speed, 115 V) at constant speeds. That is to say, the speed of revolution could be varied by changes in pulley size, but once a size was chosen, the speed remained constant. Knowing the circumference of the drum and the speed at which it traveled, then, it was possible to compute the length of pawl necessary to provide a duration of any magnitude. By taking into account the possible error in measurement of the pawls for $D = 300$ msec. conditions, the possible error due to the difference between "time on" and "time off" lags, errors made in measuring the drum circumference and the slant of the pawls, and the error made in timing the drum speed (± 5 msec.), it was ascertained that a duration of 300 ± 20 msec. was maintained, for $D = 300$ msec. conditions, throughout the experiment. To present $D = 150$ msec. conditions, the $D = 300$ msec. pawls were also used and the speed of revolution was doubled. Conditions of $D = 150$ msec. were accurate, then, to 150 ± 12.5 msec. Another pair of pawls was used for $D = 5000$ msec. conditions. These durations were accurate to 5000 ± 500 msec. It would be well to point out here that accuracy was not quite as important at $D = 5000$ as at $D = 150$ and 300 msec., because adaptation takes place before cessation of Ss. (This is suggested by Nafe and Wagoner's data (1941b), and it was also borne out by a great deal of preliminary investigation into the matter, and subsequently, by the introspective reports of the Os used in the present study. The same sources of evidence, with particular emphasis on the former, were used to ascertain that complete adaptation does not take place before cessation of stimuli whose durations are only 150 and 300 msec.)

The various time intervals between Ss were achieved by rotating one of the microswitches around the frame on which it was secured until

the appropriate distances between microswitches, and consequently the onsets of the two Ss, were reached. Only one microswitch was moved to achieve any given TI, the other remained in constant position. The appropriate distances between the rollers for each TI were determined; then these distances were marked on the drum so that possible time interval errors would be constant or nearly so. The TIs for $D = 300$ and 5000 msec. conditions were accurate to ± 13 msec. and for $D = 150$ msec. to ± 9 msec.

The metal drum and its associated paraphenalia were completely housed in a fibre board box lined with cotton batting, in order that the "clicks" produced by activation of the microswitches be greatly reduced in intensity. About two-thirds of the front panel was hinged so that access could be made to the interior for the purpose of making the necessary manipulations to the microswitches. A 7.5 W. lamp was suspended from the roof of the box.

Other materials used in this experiment were the following: A 2'x3' screen of black cloth tacked to a wooden frame was used to shield the kinohapt from O's view when he was in testing position. A black box covered the kinohapt until O took this position; after he did so, the box was removed by E.

Os were tested in supine position on a 2 1/2'x5' table which was placed parallel to the one on which the kinohapt was located. To insure Os' comfort, an air mattress and several pillows were used. To make the arm rest more comfortable a strip of foam rubber the length of the arm rest was inserted in it. An Ace elastic bandage was used to secure O's arm in position. The kinohapt rested on a sheet of foam rubber so that the table would not serve as a resonator for the sound waves generated by the action of the solenoids (which otherwise were inaudible to O).

The distance between the two needles was measured by a ruler with 1/50 in. separations. Vernier calipers were used to measure the distance

of the needles from O's arm. A device similar to a bed serving tray, except that the top slanted down toward O at a 60° angle, was used in the portions of the experiment which necessitated O's writing. Os' stimulated arms were swabbed with alcohol at the outset of each session (though this proved to be unnecessary). Cotton and ear muffs were used so that O perceived absolutely no auditory Ss associated with the apparatus.

Procedure. -- Stimuli of $D = 150, 300$ and 500 msec., $SS = 1.00, 2.00, 3.00, 4.00$ and 5.00 in., and TI from offset S_1 to onset S_2 (for $D = 150$ and 300 conditions) = $-150, -75, 0, 75, 150,$ and 300 msec., and TI from onset to S_1 to onset S_2 (for $D = 5000$ msec.) = $0, 75, 150,$ and 300 msec. were used. The following are the two-point stimulations which were used: All possible combinations of $D = 150$ and 300 msec., $SS = 1.00, 2.00, 3.00,$ and 4.00 in., and TI = $-150, -75, 0, 75, 150,$ and 300 msec. were presented, a total of 48 different conditions. Conditions of $D = 5000$ msec. were combined with $SS = 1.00, 2.00, 3.00,$ and 4.00 in. and TI (from onset to onset) = $0, 75, 150,$ and 300 msec. for a total of 16 unique conditions. In addition, all three durations were used with TI = 300 msec. and $SS = 5.00$ in., so there were three conditions of $SS = 5.00$ in. And finally, one-point stimulations were presented, two for each duration or six in all. There was a total, then, of 73 conditions.

Os were run on 14 separate sessions; all except the first two sessions were approximately one hour in length (the first two were shorter). All Os except AC had one session per day, six sessions per week. Observer AC had two sessions per day, twelve per week. Her same-day sessions were one hour apart. (This treatment of AC was, unfortunately, a necessary concession to her participation in the experiment.)

Each O's 14 sessions were held at approximately the same hour each day. Two Os were run at the early to mid-morning hours, two were run in mid-afternoon, and the other was run at the late afternoon to early

evening hours. The first two sessions were orientation sessions, the next six were practice sessions, and the final six were experimental sessions.

Fourteen conditions were selected randomly from the total of which six were presented to Os on the first session and eight on the second session. These 14 conditions were used to orient Os to the experiment and the experimental conditions. After the orientation sessions, two complete sets of the 73 conditions were presented, the first set as practice conditions, the second set as experimental conditions.

Two sets of semi-random orders of the 73 conditions were made up for each O. The orders were determined thusly: Twelve conditions were presented on five of the practice and experimental days and thirteen on the remaining day. Seventy-three slips of paper of equal sizes, each specifying a stimulus condition, were made up. All conditions of $D = 150$ msec. were clipped together as were those of $D = 300$ and 5000 msec. These three bundles were placed in a shoe box and shaken. Two of the three were selected for use on a single session. Each one selected was separately unclipped, placed back in the box and shaken, and then 6 conditions were drawn from the box; consequently, 6 conditions each of two durations were chosen for a single session. (The split was not exactly 6-6 on one or two of the sessions since there were fewer $D = 5000$ than $D = 150$ and 300 msec. conditions.)

The conditions were not completely randomized since a great deal of time was required to manipulate the apparatus from condition to condition for all three stimulus variables. It was decided to only partially randomize duration for two reasons. First, because the variable of duration was not believed to be as crucial or significant in the determination of apparent movement as were the other S variables, as indicated by the results of previous studies and those of the present author's pilot study, and second, it took longer to manipulate the apparatus for changes in D than for the other variables, since to change from $D = 150$ to $D = 300$ and vice versa, it was necessary to change gear size and this change

necessitated a check on the drum speed. (Before each session and in mid-session when D was changed, the drum speed was carefully checked so that the speed of the drum was always 2450 ± 5 and 1225 ± 5 msec.

Each condition, when it was presented, was presented 3 times in succession. For the D = 150 and 300 msec. conditions, each of the three trials constituted two identical successive stimulus presentations, that is the drum revolved twice when conditions of these durations were being presented. Two presentations were given because in preliminary investigation, it was found that with conditions this short in time, Os had difficulty making reliable responses, since, as the pilot study O reported, "The stimuli had come and gone almost before I realized I was stimulated." Os were told to respond only to the second presentation, if possible, and that the first one was simply to alert them to the impending arrival of the second. Only one presentation per trial was given for D = 5000 msec. conditions, since it was expected that if two presentations were given, the skin would not recover sufficiently after the first for the second to be perceived as clearly and vividly as the first.

As already stated, the same conditions were given in practice sessions as were given in the experimental sessions (although the orders were different). The responses made during the practice sessions were verbal responses; Os were told to describe or relate their tactual impressions in their own words. During the experimental sessions, Os reported their impressions by selecting the appropriate characterizations from a key (Appendix A). Further elaboration of the different procedures used in the practice and experimental sessions is forthcoming; the difference is suggested here so that the purpose of the two types of sessions can be explicated. The principal purpose of the practice sessions was, of course, to develop previously inexperienced Os (with respect to participation in a tactual study) into practiced Os. The reports from these sessions also were used to aid in the determination of which diagrams

would be most suitably included in the key to be used in the succeeding portion of the experiment. All of Os' verbal reports were recorded by E with paper and pen. So although a complete set of verbal reports for each O was thus obtained, it was believed that these reports would not suitably be considered as constituting primary data, subject to analytical operations performed for inferential purposes. The results from the experimental sessions were so considered. The bases for these designations were that in the practice sessions, a) the degree of skill in reporting changed, probably exponentially, b) Os did not have a common set of criteria for responding, and c) the classification of the verbal responses depended, too often, on E's interpretation of them, while in the experimental sessions, the procedure used was assumed to have obviated these difficulties. However, the intention was to use the verbal reports to establish, though only roughly perhaps, the degree of consistency of Os' responses.

The first 8 days of experimentation, consisting of the orientation and practice sessions were called Part I of the experiment. At the outset of the first session of Part I, Os were given the following instructions to read:

This study is concerned with the tactile or touch modality. By means of a specially-built machine, I am going to present a series of points (tactile Ss) to the inside surface of your arm. Your arm will rest in a foam rubber-covered tray and will be secured in place by an elastic bandage. It is essential that you remain still while your arm is in place on the arm rest. So that you will be as comfortable as possible during the experiment, you are to lie down on the air mattress and extend your arm onto the arm rest, using the pillows to give your head support. You are to put cotton in your ears and put on the ear muffs. Please keep your eyes closed during the tactile presentations; you may, nonetheless look around the room between trials. Do not, however, at any time, look behind the black screen which shields the kinohapt from your view.

I will give the signal, "Ready, " before each trial. At this signal, you are to close your eyes and wait passively for the contacts to be

made on your arm. Approximately $2/3$ of the time, a trial will consist of two identical tactile presentations, and in the remainder of cases, one presentation will be given per trial. I will tell you ahead of time which of the two cases is forthcoming. When a trial consists of two presentations, respond only to the second one if possible. The first presentation will simply serve as a signal to alert you for the second. Immediately after each trial, I want you to tell me about or describe to me the impression or impressions you had from the tactile Ss. Tell me all you can about your impressions in as detailed a manner as you feel necessary to insure that your impressions are communicated to me.

The time interval from the end of one trial to the beginning of the next is at least 45 sec. It will be longer if it takes me longer than this to write down your response from the preceding trial. Periodically, you will have short rest periods in which you will be able to move your arm about and flex your fingers. [This was done between conditions, or after every three trials.] If at any time your arm feels strained or tired, please tell me and you can take your arm out of the tray for a few minutes. [This was usually done mid-way through a session, while E was changing and checking the drum speed.]

The first two days of experimentation consist of orientation trials, which will permit you to get oriented to the experiment and the experimental conditions. During this period, it is particularly important that you ask questions or make remarks concerning any phase of the experiment about which you are in doubt. Are there any questions?

The non-dominant arm of each O was used. Between each condition, the positions of both needles were changed. Spatial separations were in error only as much as the ruler used to measure them was in error, because the ruler was placed flush against the two needles. The needles for the conditions of $SS = 1.00$ in. were placed mid-way between the elbow and the wrist, and for progressively larger separations, the needles were placed progressively closer to the elbow and the wrist. The perpendicular distance from the needle tips to the arm was measured with calipers, and care was taken to insure that the needles did not fall on hairs. (One O shaved his arm periodically during the experiment because the hair on his arm was so dense that this situation was difficult to achieve.)

At the outset of Part II of the experiment, Os were instructed that although most of the procedure was to remain unchanged, their method of reporting was not. These additional instructions were read by O at the beginning of the first experimental session (the instruction sheet was called Sheet 1):

You are to use the diagrams given on Sheet 2 [see Appendix A] to characterize the impressions you have from the various types of stimuli. Study the diagrams carefully. Be sure to ask any questions that come to mind concerning the diagrams and the impressions they are intended to represent.

It is possible that you will not be able to find a diagram suitable for characterizing a given impression. In this event, you are to draw one that is appropriate on the sheet supplied you for your responses [see Appendix B]. For all other impressions, i.e., those suitably represented by diagrams, you are simply to write down, on this data sheet, the general class of the impressions, either A, B, or C, corresponding to simultaneous, successive and movement impressions, and the specific type of impression within a given class, by writing 1, 2, 3, etc., as the case may be, on your data sheet. For example, if you have an impression which can be characterized by this diagram: , you are to write A-3 on your data sheet.

In addition to selecting or drawing a diagram to characterize your impression, you are to further describe it by reporting on the perceived nature of the departure of the stimulating object(s) from the skin. The response categories are listed on Sheet 2, following the diagrams, along with the key you are to use in making these responses, e.g., FP and SP.

You will receive 12 stimulus conditions per day with 3 trials per condition. Your data sheet provides a line for each one of the 36 responses you will make per session. The column headings indicate in what order you are to write the three components of each response, e.g., A-3-SP. If you need to draw a diagram, do so in the blank space provided on the right side of the data sheet. Be sure to label the diagram with the appropriate condition number and trial letter. When you have finished categorizing a response, indicate to me that you have done so.

After they read the instructions, Os were then shown the slanted writing tray and its use was explained. When O was in testing position, the tray was placed in front of him so that he could readily see the diagrams

and could easily record his responses. (The set of diagrams and a data sheet were tacked on the tray before the beginning of each experimental session.)

Since it was found in the practice and experimental sessions, contrary to hypothesis, that apparent movement can occur in the absence of offset of S_s , i. e. at $D = 5000$ msec., it was supposed that it would be more meaningful and fruitful to consider time intervals, not from offset of S_1 to onset of S_2 , but from onset to onset. (If one knew precisely when complete adaptation to a stimulus of given duration took place, one could call this S offset, and measure the temporal distance from this point to the onset of S_2 , but unfortunately complete adaptation time varies considerably, depending on skin texture and condition, weight of S , etc.) Converting the time intervals used in this study from the former to the latter measurement scheme, one obtains, for $D = 150$ msec., $TI = 0, 75, 150, 225, 300$ and 450 msec., for $D = 300$ msec., $TI = 150, 225, 300, 375, 450$ and 600 msec. The TIs for $D = 5000$ msec. were, of necessity, initially defined from onset to onset, and were $0, 75, 150$, and 300 msec. In order to compare durations at onset to onset TIs , then, it was necessary to supplement these above TIs with the following additional conditions: at $D = 150$ msec., $TI = 375$ and 600 msec., at $D = 300$ msec., $TI = 0$ and 75 msec., and at $D = 5000$ msec., $TI = 225, 375, 450$, and 600 msec.

All of these supplementary conditions were presented except $D = 300$, $TI = 0$ (which was not since it was expected that $\underline{O}s$ would experience these conditions as simultaneous and/or single impressions and these experiences were not particularly of interest) at all four of the major SSs , i. e. at $SS = 1.00, 2.00, 3.00$, and 4.00 in., for a total of 28 additional S conditions. These conditions were given on two successive days, 14 conditions per day, to the 4 $\underline{O}s$ who reported apparent movement in the earlier sessions (one reported none in either the practice or experimental sessions). The procedure maintained was precisely that used throughout

the earlier experimental sessions. Approximately 6 wks. to 2 mos. separated these two supplementary experimental sessions from the earlier six.

The purpose and the hypotheses of the experiment were briefly discussed with Os at the end of their 14th session; the distinction between on- and off-skin movement, both experiential and mechanistic, was suggested in this discussion. Although it was feared that this discussion might influence Os' reports in the subsequent additional sessions, it was hoped that since 6 wks. to 2 mos. had passed since the 14th sessions, Os would not recall details of the discussion, or that if they did recall it, it would have no bearing on their responses.

The results from experimental sessions 1-6 will be treated in the initial portions of the following chapter, and subsequently, the data obtained during sessions 7-8 will be presented. Until and unless otherwise stated, the results reported in the succeeding chapter pertain to conditions for which TI indicates offset-onset temporal separation between S_1 and S_2 .

CHAPTER IV

RESULTS

Observer AC (female, age 37) reported no apparent movement whatsoever throughout the course of the experiment. During the second orientation session, she exclaimed after one presentation that, "It seemed like that moved but I just know it couldn't have; I must be cracking up. I don't know what to believe is real anymore." She was immediately told by E not to report what she thought S was, but to describe what her experiences to S were as fully and accurately as she possibly could, no matter how unusual and unreal they seemed. However, after this occasion, AC never again mentioned movement except in reporting what she called "radiating after-effects," which she described as "tingling going out in all directions" from the point of contact after the stimulating objects were experienced as withdrawn. It is not known, of course, whether she did experience movement again and simply was too embarrassed and ashamed to admit that she had had such "crazy" experiences, or whether she did not further experience tactual movement. At any rate, AC's results will not be considered henceforth in the presentation of the results.

The other 4 Os each reported several types of tactual apparent movement. In addition to the 12 movement diagrams included on Os' key (Appendix A), 8 other types of movement impressions were represented by them with additional diagrams. These 8 were all variations of C11 and C12 impressions, that is, all represented off-skin movement of one sort or another. Some showed movement only part way between the two end points, others showed one or both end points to be blunt (represented by the hatched circle), some showed various combinations of movement

low and flat over the skin (C11) for part of the distance between the two end points with bow movement (C12) over the remainder. On-skin movements, then, were represented by diagrams C1-10 and off-skin movements by C11-20.

Throughout this paper, movement experiences, when considered, will be reported in terms of a) proportion of all types of movement combined, b) proportion of on-skin movement, and c) proportion of off-skin movement, where the proportions are the relative frequencies for the S condition(s) in question. (At a later time, analyses will be made of the frequency of different types of on-skin at the 4 SSs and 6 TIs; for the present all types of on-skin and all types of off-skin movement are considered collectively.) And unless otherwise stated, the results reported are those obtained strictly from the experimental conditions exclusive of the one-point and 5.00 in. S conditions.

The total, on- and off-skin proportions of movement for Os singly and combined at each of the three S durations are given in Table 1. As can be seen, and as was indicated previously, movement was reported for D = 5000 msec., contradicting hypothesis 5. The results relevant to each of the 6 hypotheses will be presented in the order as were the hypotheses, so that this matter will be elaborated further at the appropriate time.

1. Relation of TI to SS. It was hypothesized that S conditions of D = 150 and 300 msec. with high movement response probabilities were those for which TI and SS were directly related, particularly those conditions at the extreme TI and SS levels (with the exclusion of simultaneous TI conditions). This hypothetical relation of TI and SS to proportion of movement is expressed graphically in Fig. 2. (It was expected that if TI and/or SS were increased to a sufficiently great extreme, experiences of movement would no longer occur, but just what constitutes sufficiently

great extremes was not known. TI = 300 msec. and SS = 5.00 in. conditions will be expressly considered in this regard.)

Table 1. Proportion of On-skin, Off-skin and Total Movement Responses at D = 150, 300, and 5000 msec.

<u>O</u>		D			All Ds Combined
		150	300	5000	
TT	On	.11	.11	.25	.15
	Off	.19	.15	.04	.14
	Total	.30	.26	.29	.29
TN	On	.53	.47	.46	.49
	Off	.22	.26	.08	.20
	Total	.75	.73	.54	.69
AlC	On	.26	.24	.31	.26
	Off	.11	.17	.12	.14
	Total	.37	.41	.43	.40
JR	On	.06	.15	.00	.08
	Off	.08	.22	.08	.14
	Total	.14	.37	.08	.22
Combined					
<u>Os</u>	On	.24	.24	.26	
	Off	.15	.20	.08	
	Total	.39	.44	.34	

The obtained results for the 4 Os combined at TIs from -150 to 300 msec. and SSs from 1.00 to 4.00 in. for D = 150 and 300 msec. conditions are presented in Fig. 3. At TI = -150 msec. only D = 300 msec. results are included, because at D = 150 this TI constituted a simultaneous two-point presentation for which it was expected that Os would make Class A responses. Notice also that the results of the 5.00 in. conditions are presented.

Only at TI = 75, 150 and 300 msec. are the obtained proportions at all similar to the predicted proportions. It would appear that SS is an

important variable in the determination of amount of movement only at the larger TIs (at least for the SSs and TIs presented in this experiment).

2. Relation of TI to D. It was expected that TI need not be inversely related to D in order to maximize apparent movement; it was, in fact, thought somewhat likely that amount of movement would be similar for both D = 150 and 300 msec. conditions at the various TIs. The obtained results (for all Os and SSs combined) are presented in Fig. 4. The inverse relation was, as expected, not evidenced, but the two curves bear only a loose similarity. (The points on the curves at TI = -150 msec. should not be compared, since they were not expected to be similar.)

3. On-skin movement as a function of TI and SS. The predicted relative frequencies of on-skin movement at each combination of the 4 SSs and 6 TIs are shown in Fig. 5. The results obtained for the 4 Os at D = 150 and 300 msec. conditions, shown in Fig. 6, do not support this prediction. Roughly speaking, only a rather gradual decrease in proportion of on-skin movement as a function of TI for all SSs was obtained.

If variations in the size of SS did not appreciably affect the amount of on-skin movement, the quality of on-skin movement was greatly affected by such variations. It was expected that the smaller the SS, the greater would be the extent or completeness of the movement on the skin, and the larger the SS, the lesser would be the completeness. For example, it was expected that at SS = 1.00 in. more full movement, continual on-skin movement from point 1 to point 2, would be reported than at the other SSs, and that inner movement, back and forth movement restricted to a small circular area around the end points, would more likely occur at SS = 4.00 in. than at the other SSs. On-skin movement was classified according to the following three decreasing levels of completeness: A) full movement, represented by diagrams C8, 9, and 10 in the response key (Appendix A),

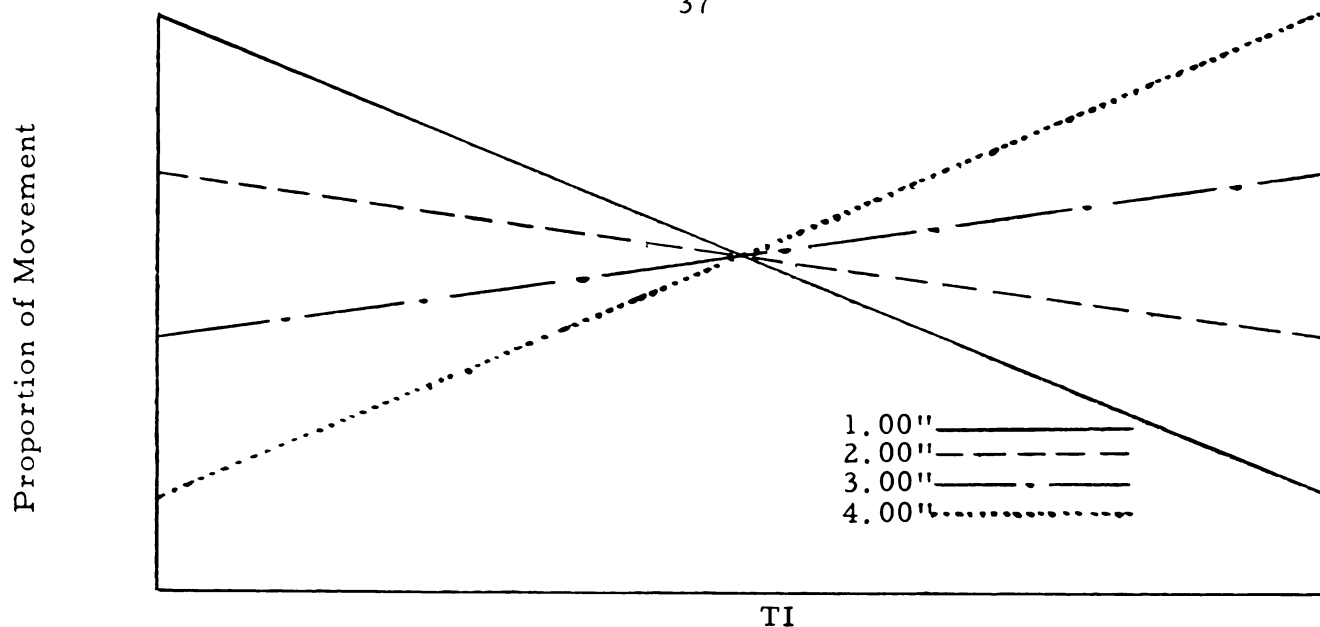


Fig. 2. Theoretical Proportion of Movement as a Function of TI for SS = 1.00, 2.00, 3.00 and 4.00 in.

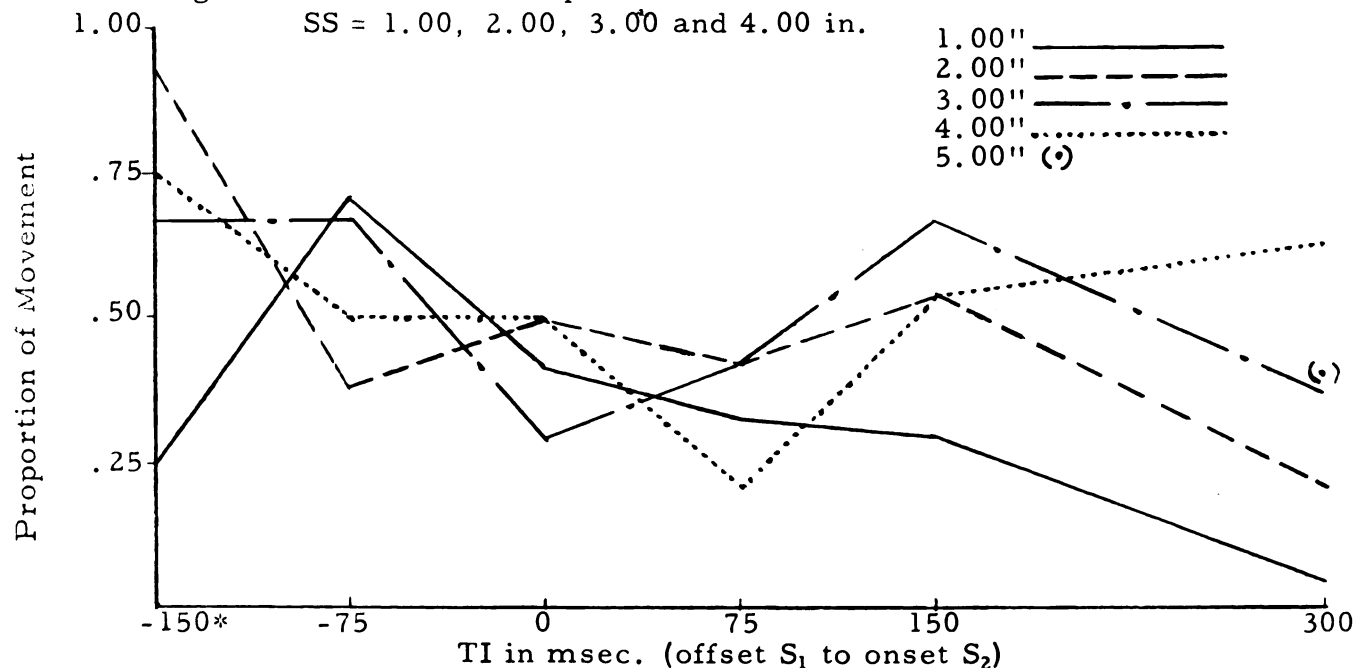


Fig. 3. Obtained Proportion of Movement as a Function of TI for SS = 1.00, 2.00, 3.00, and 4.00 in. at D = 150 and 300 msec.

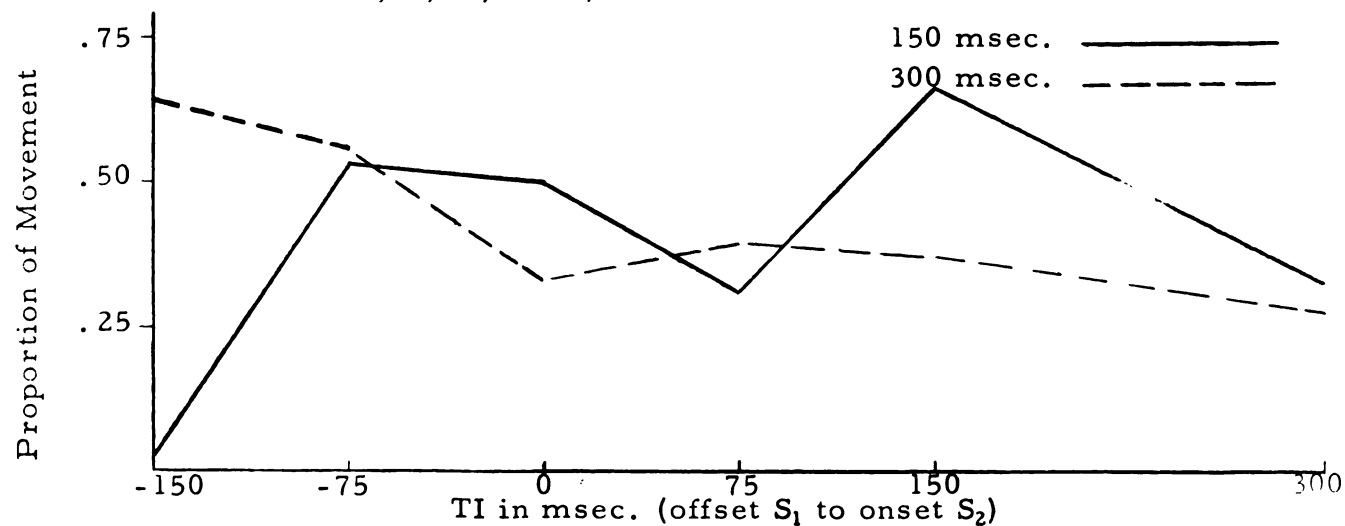


Fig. 4. Obtained Proportion of Movement as a Function of TI for Combined at D = 150 and 300 msec. Conditions.

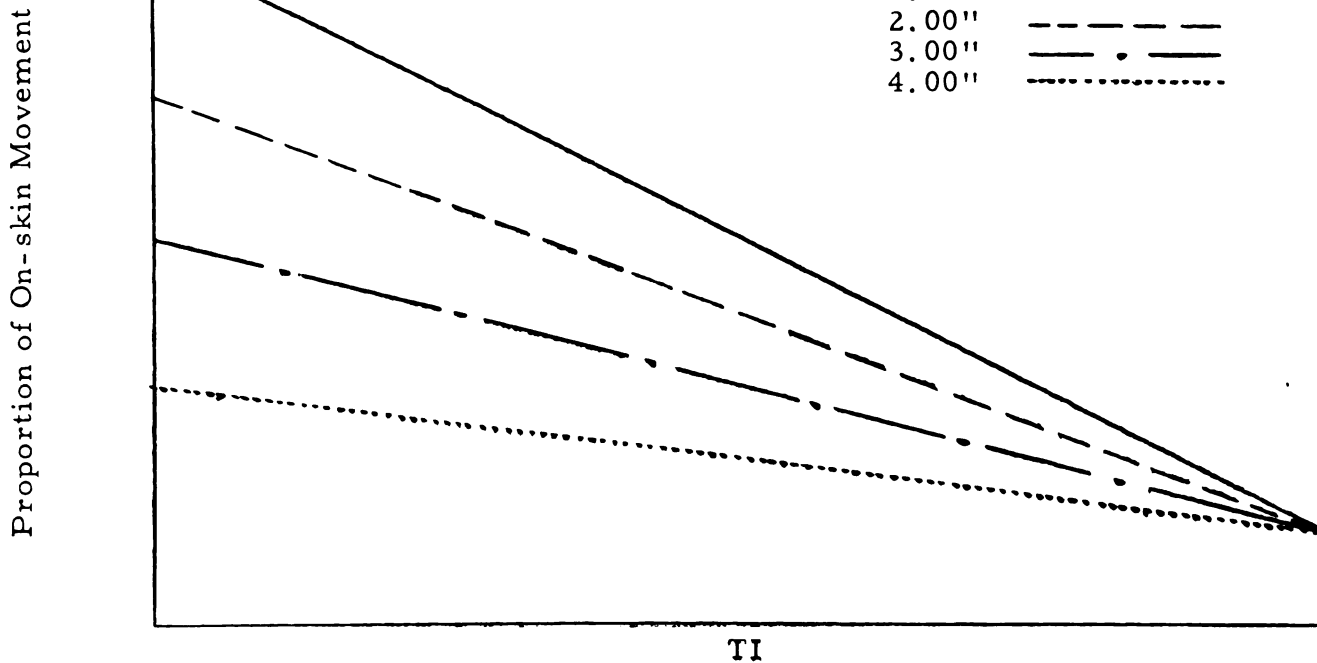


Fig. 5. Theoretical Proportion of On-skin Movement as a Function of TI for SS = 1.00, 2.00, 3.00, and 4.00 in.

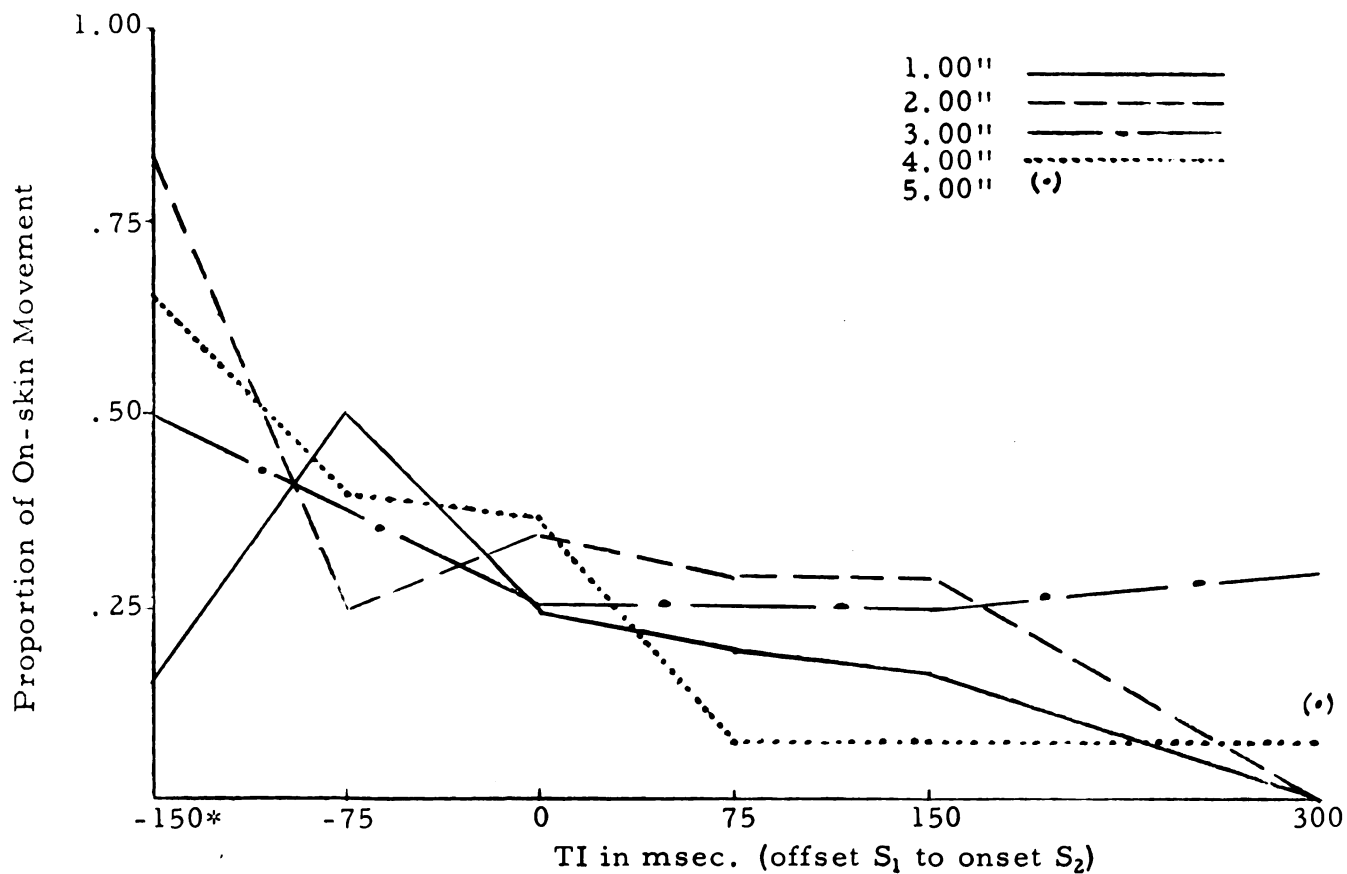


Fig. 6. Obtained Proportion of On-skin Movement as a Function of TI for SS = 1.00, 2.00, 3.00, and 4.00 in. at D = 150 and 300 msec. Conditions.

*Only S conditions of D = 300 msec. included.

B) end movement, partial movement between points 1 and 2, represented by diagrams C1, 2, 3, and 4, and C) inner movement, represented by diagrams C5, 6, and 7. In Table 2 are presented the relative frequencies of each of these classes of on-skin movement at each SS from 1.00 to 4.00 in. for all Qs and all two-point conditions presented in the initial 6 experimental sessions. The obtained relative frequencies for the 4 SSs support amazingly well the expected relation. Full movement constituted 61% of on-skin movement at SS = 1.00 in. conditions, and decreased continually until at the 4.00 in. conditions no full movement was reported. End movement increased from 39-69% and inner movement increased from 0-31% as SS was increased from 1.00 to 4.00 in.

A similar determination of relative frequencies of these three classes of on-skin movement as a function of TI was made. (Only D = 150 and 300 msec. conditions were included here, since TIs for D = 5000 were not comparable to those for 150 and 300.) A summary of the results obtained is presented in Table 3. Type of on-skin movement is, evidently, not nearly as dependent on TI as SS, although as might be expected, full movement is not common at large TIs, and end movement is most common at TI = 300 msec.

Analyses comparable to the two preceding ones for off-skin movement were not made since only three partial off-skin movement responses were reported in the entire study.

4. Off-skin movement as a function of TI and SS. The theoretical and obtained proportions of off-skin movement responses are graphically presented in Figs. 7 and 8, respectively. The obtained results can be seen to bear some similarity to the predicted results. The results obtained indicate that at TI = -150 to 75 msec., SS does not noticeably influence proportion of off-skin movement, while at TI = 150 and 300 msec. it does so and generally in the manner predicted (SS = 3.00 in., TI = 300 msec. conditions excepted).

Table 2. Relative Frequencies of the Three Types of On-skin Movement at SS = 1.00 to 4.00 in.

Class of On-skin Movement and Typical Member	SS			
	1.00	2.00	3.00	4.00
Full o → o	.61	.38	.22	.00
End o → → o	.39	.61	.67	.69
Inner 	.00	.01	.11	.31

Table 3. Relative Frequencies of the Three Types of On-skin Movement at TI(offset S₁ to onset S₂) = -150 to 300 msec.

Class of On-skin Movement and Typical Member	TI					
	-150	-75	0	75	150	300
Full o → o	.23	.46	.26	.26	.05	.00
End o → → o	.70	.49	.70	.58	.95	.78
Inner 	.07	.05	.04	.16	.00	.22

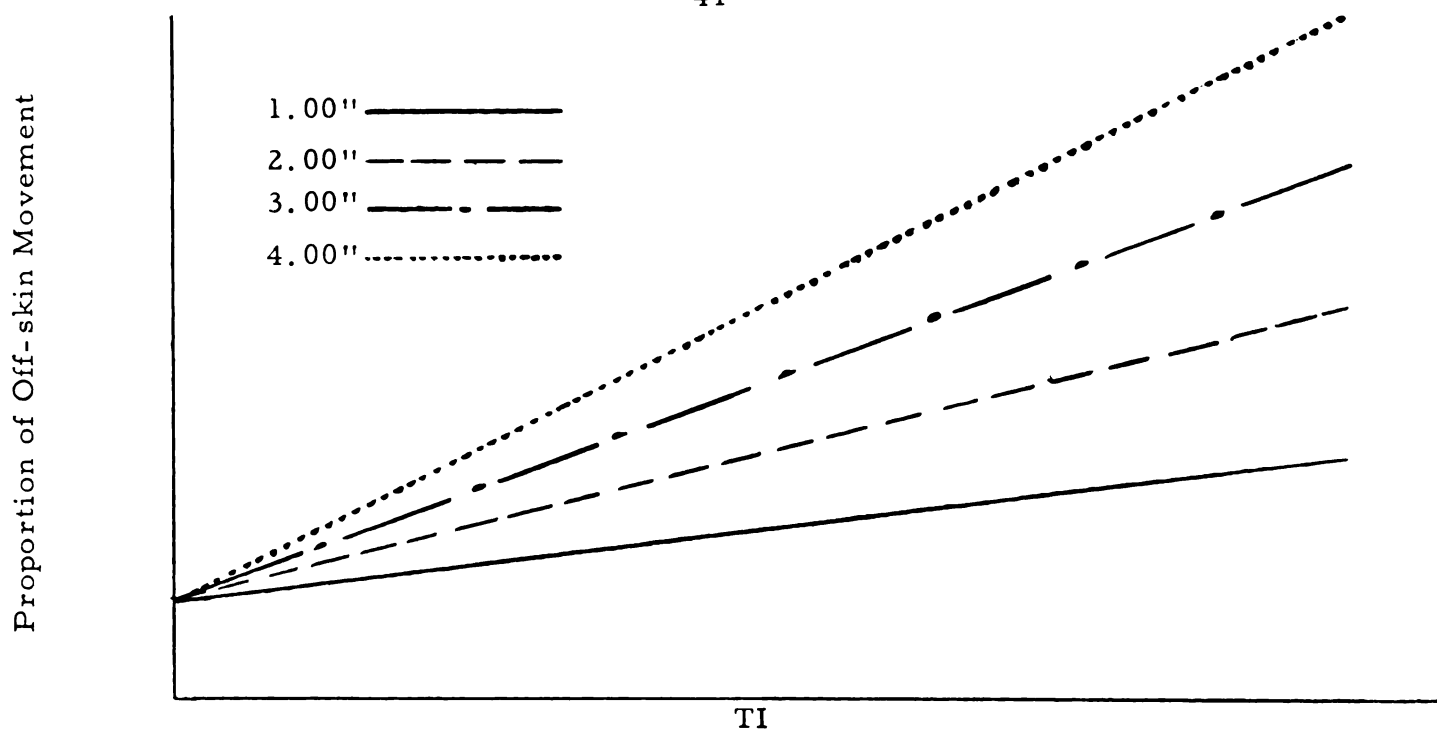


Fig. 7. Theoretical Proportion of Off-skin Movement as a Function of TI for SS = 1.00, 2.00, 3.00, and 4.00 in.

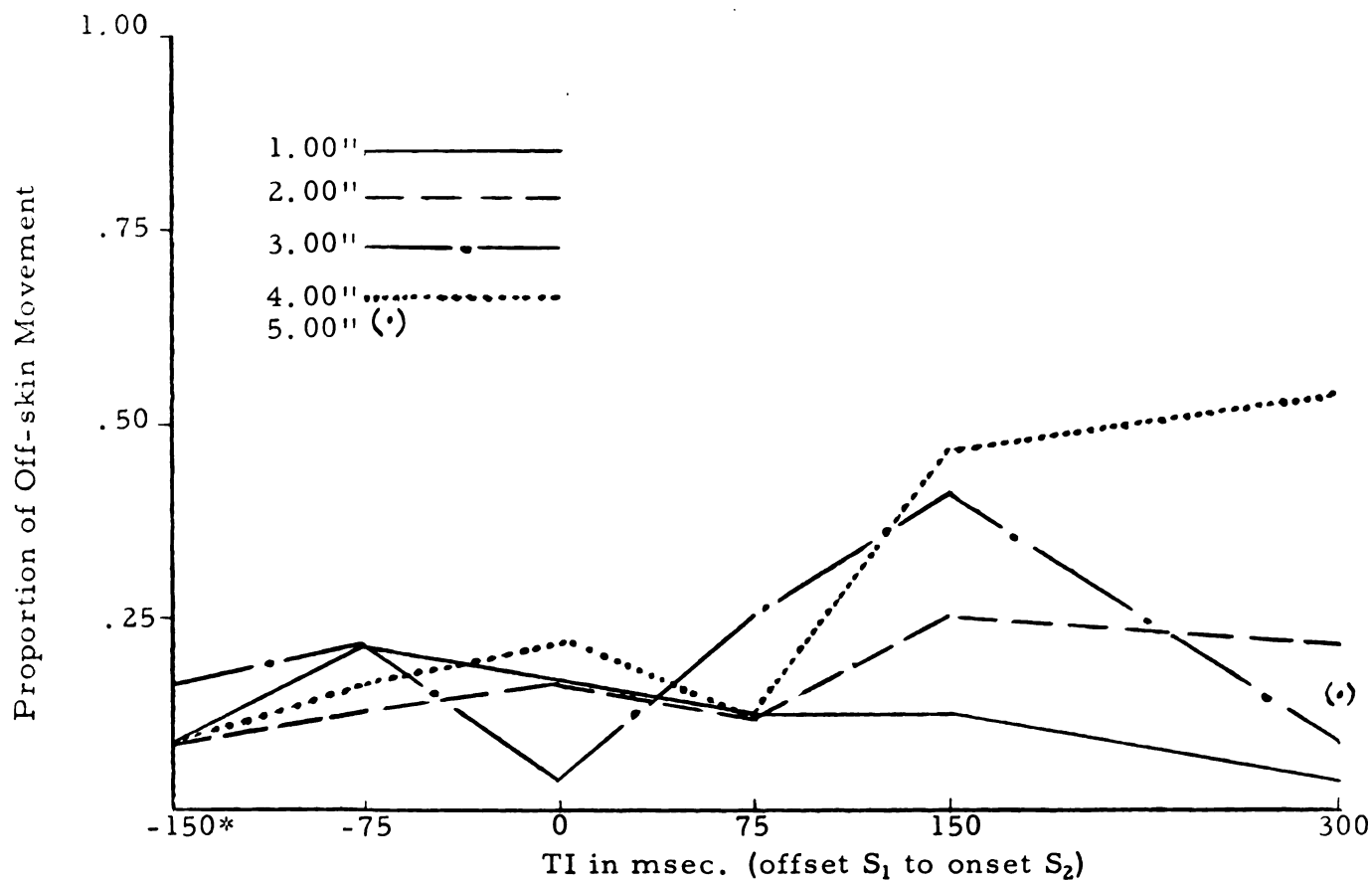


Fig. 8. Obtained Proportion of Off-skin Movement as a Function of TI for SS = 1.00, 2.00, 3.00, and 4.00 in. at D = 150 and 300 msec. Conditions.

*Only S conditions of D = 300 msec. included

Since a meaningful distinction between on- and off-skin movement was and is considered by the author crucial to an understanding of apparent tactual movement in general, it therefore, would afford a basis for new contributions in the area of apparent movement. It would be well, then, to further examine the results obtained regarding on- and off-skin movement.

Except at the largest time intervals, amount of movement of either variety was found to depend primarily on TI, with differences in SS contributing little to the total effect. Therefore, a consideration of amount of movement as a function strictly of TI will now be undertaken. Because they provide further insights into the identification of conditions associated with reports of on- and/or off-skin movements, the following figures are presented: 1) Fig. 9, Proportion of Total, On- and Off-skin Movement of All Os Combined, at D = 150 msec., as a Function of TI; 2) Fig. 10, Proportion of Total Movement for Each O, at D = 150 msec., as a Function of TI; 3) Fig. 11, Proportion of On-skin Movement for Each O, at D = 150 msec., as a Function of TI; 4) Fig. 12, Proportion of Off-skin Movement for Each O, at D = 150 msec., as a Function of TI; 5) Figs. 13-16, identical in nature to Figs. 9-12, except that D = 300 instead of 150 msec. As can be seen in Figs. 9 and 13, the on-skin curves for the two durations are very similar (except at TI = -150, of course), while the off-skin curves are not so. And regularity among Os is seen only for off-skin curves for D = 150 msec., thus suggesting that the two types of movement are a product of or arise from dissimilar mechanisms, and that the difference between these two durations does, after all, have significant bearing on the reports of apparent movement.

Another interesting way of examining the on- and off-skin data is the following: Hypotheses 3 and 4 of the study state that amount of on-skin movement varies with TI (and SS) and off-skin movement directly with TI (and SS). These hypotheses might otherwise have been stated that

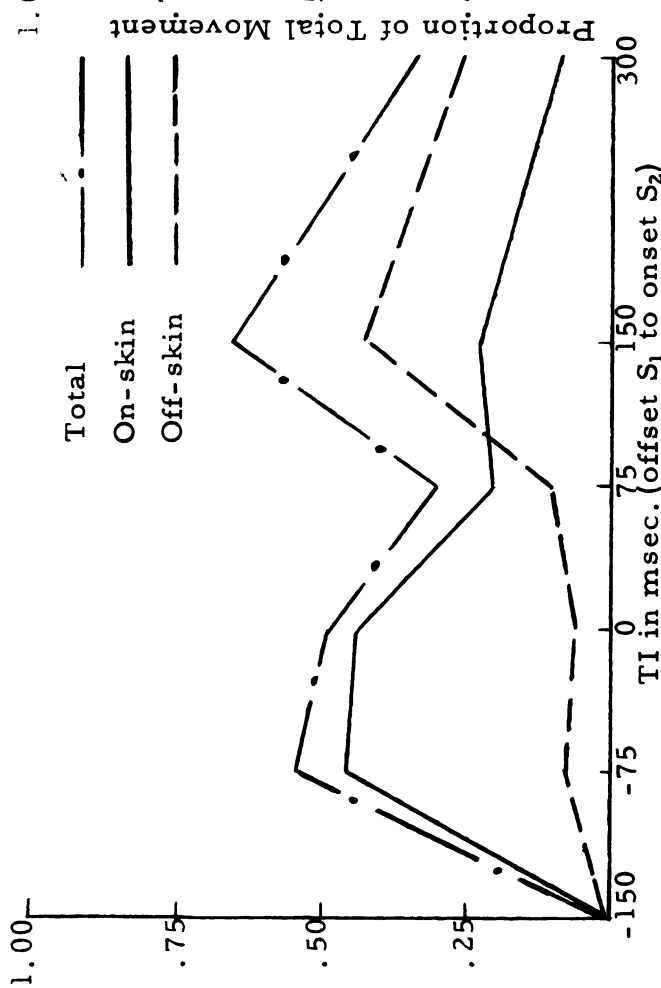


Fig. 9. Proportion of Total, On- and Off-skin Movement for All Os at $D = 150$ msec. as a Function of TI.

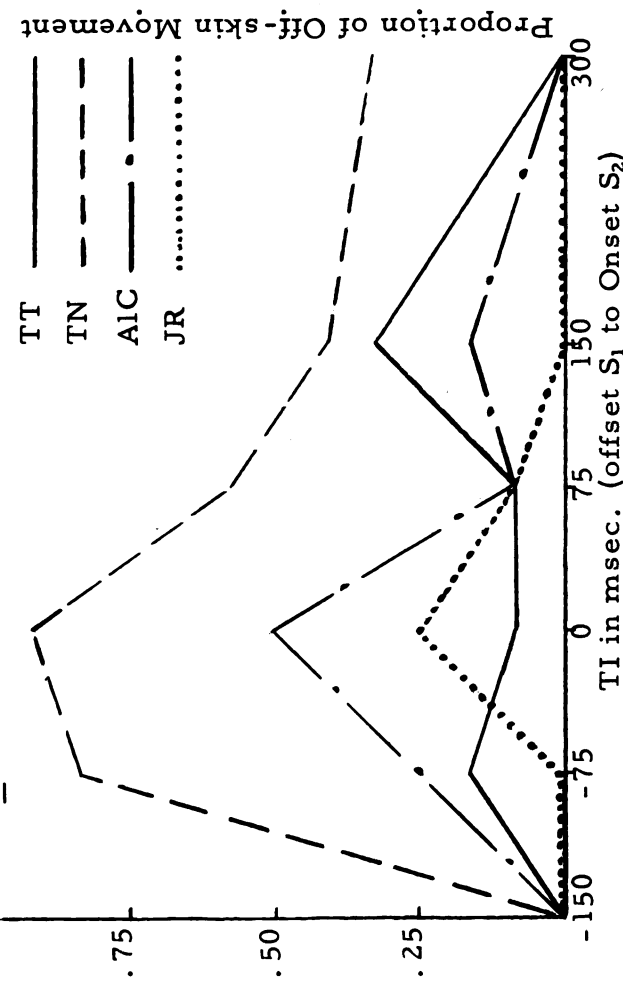


Fig. 11. Proportion of On-skin Movement for Each Q at $D = 150$ msec. as a Function of TI.

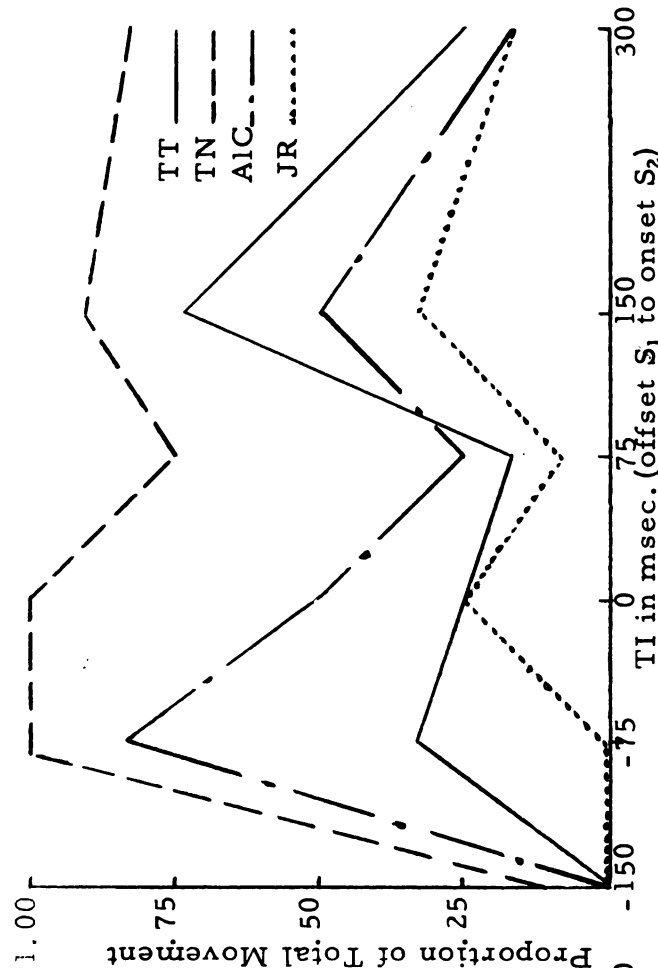


Fig. 10. Proportion of Total Movement for each Q at $D = 150$ msec. as a Function of TI.

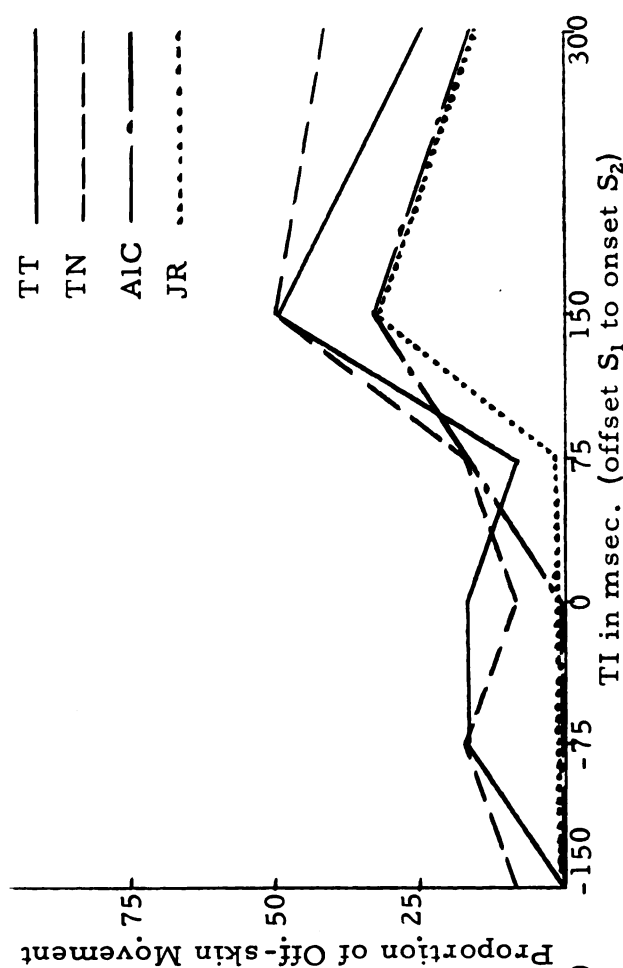


Fig. 12. Proportion of Off-skin Movement for Each Q at $D = 150$ msec. as a Function of TI.

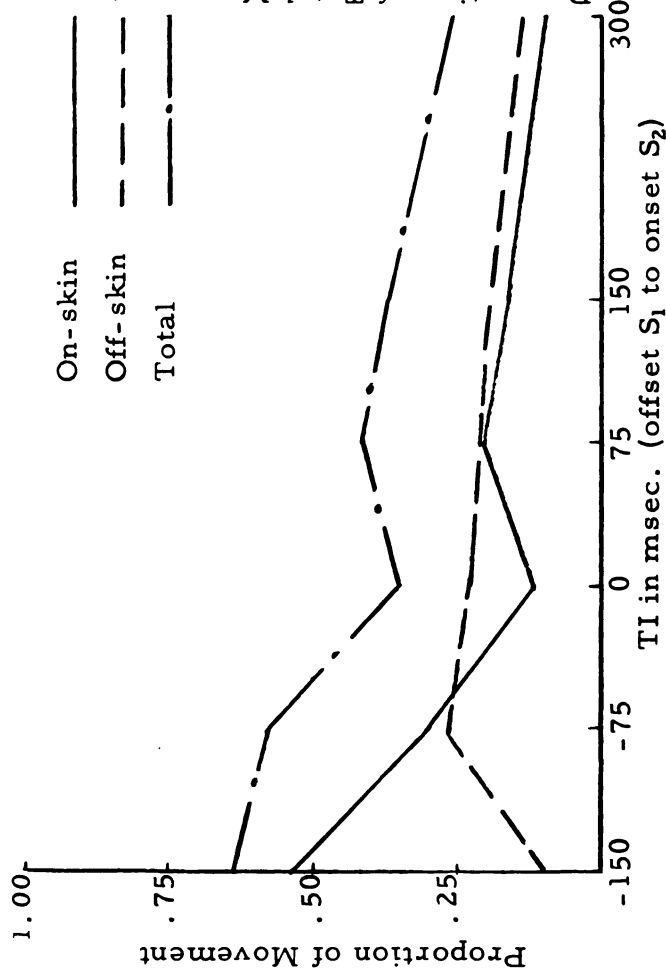


Fig. 13. Proportion of Total, On- and Off-skin Movement for all O_s at $D = 300$ msec. as a Function of T_I .

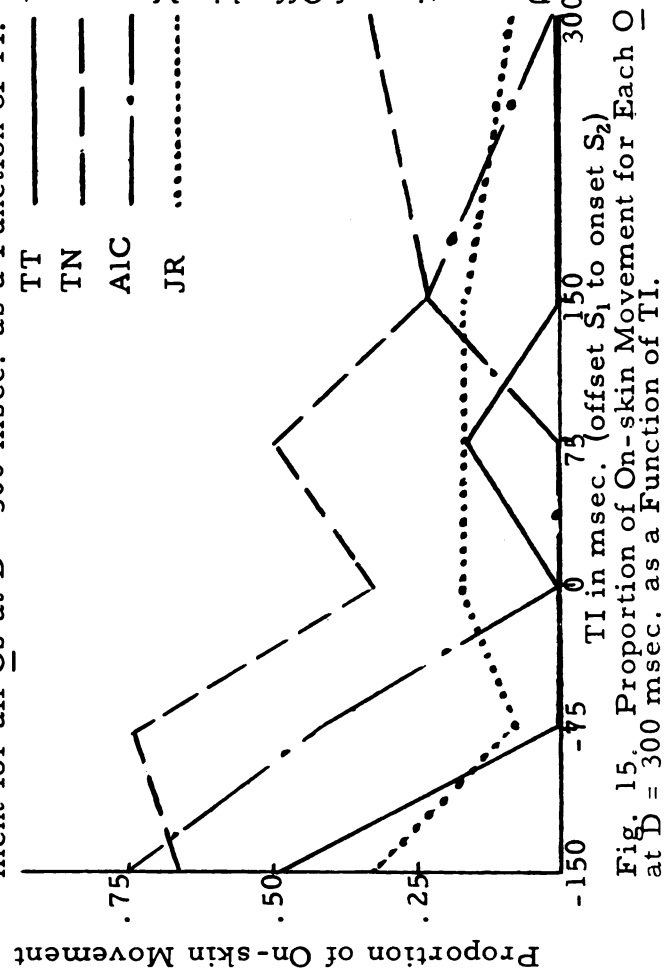


Fig. 15. Proportion of On-skin Movement for Each Q at $D = 300$ msec. as a Function of T_I .

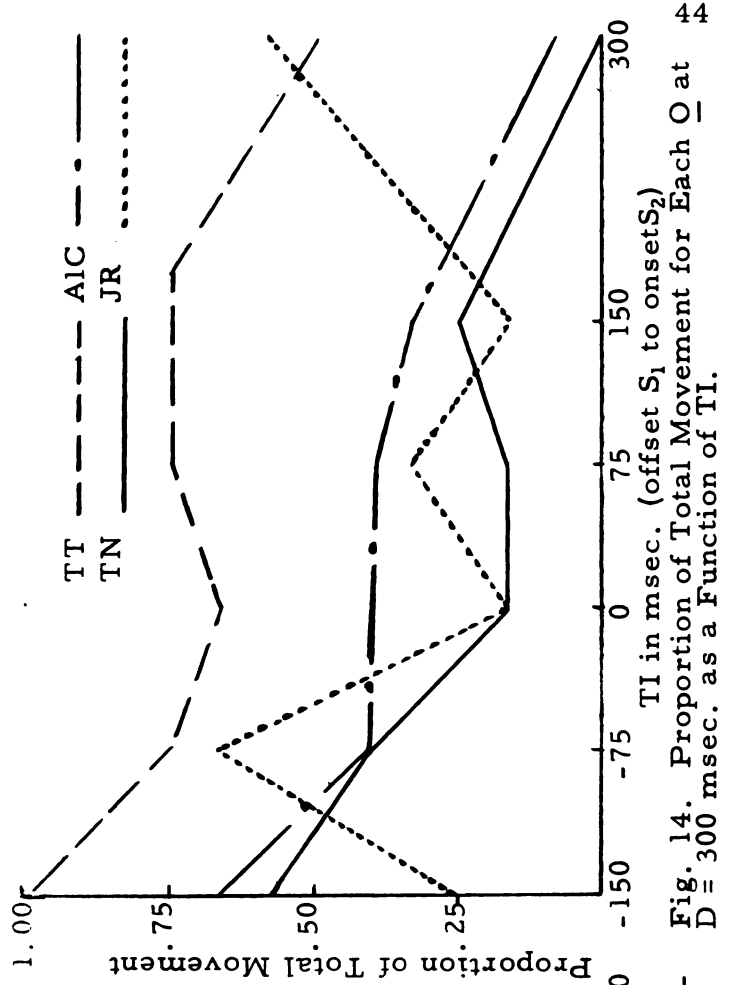


Fig. 14. Proportion of Total Movement for Each Q at $D = 300$ msec. as a Function of T_I .

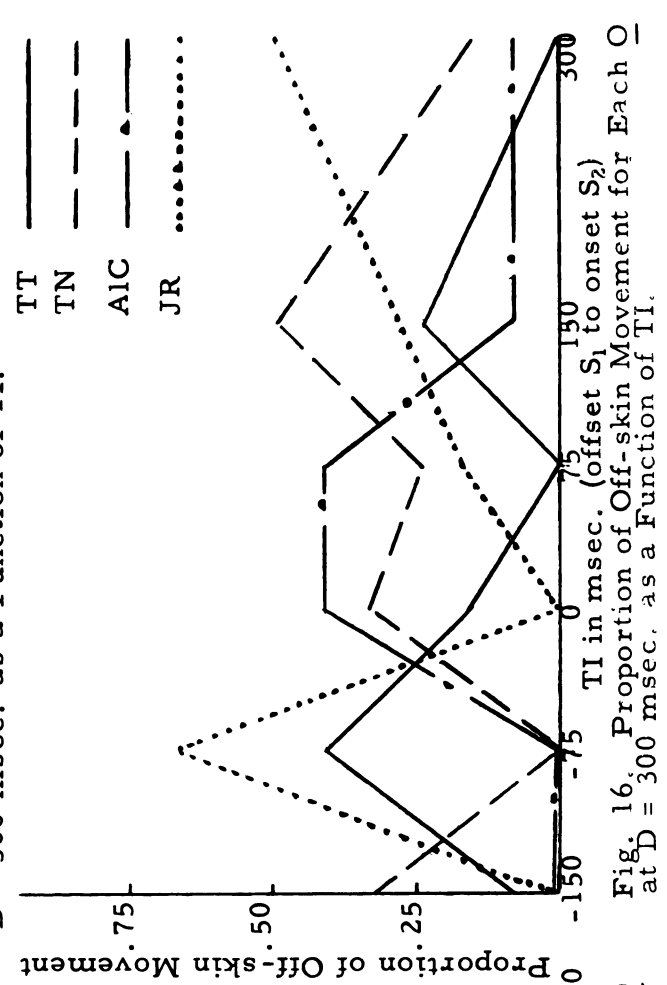


Fig. 16. Proportion of Off-skin Movement for Each Q at $D = 300$ msec. as a Function of T_I .

if movement occurs at successively shorter TIs the more likely it is to be on-skin movement, and if at longer TIs, off-skin movement. Presented in Fig. 17 are the obtained conditional proportions of on-skin movement for conditions of $D = 150$ and 300 msec., separately and combined. (The conditional off-skin proportions are, of course, 1 minus on-skin proportions.) Only at $TI = 0$ is there a departure from the expected results.

The amount of movement obtained at the various SSs is also of interest in that the proportion of on-skin movement showed a different relation to SS than did off-skin movement. In Fig. 18, on- and off-movement obtained as a function strictly of SS is graphed for $D = 150$ and 300 msec. For both durations, off-skin movement increased very slightly as a function of SS, while incidence of on-skin movement was relatively the same across SS except for peaks at 3.00 in. for $D = 150$ and 2.00 in. for $D = 300$ msec. conditions. All 4 curves are highly similar though. The on-skin curves for individual Os (not shown) were all similar; the off-skin curves, however, were of two types; one pair was relatively flat and another increased as a function of SS.

5. Apparent movement in the absence of S offset: $D = 5000$ msec. conditions. It was predicted that no movement would occur with these S conditions. Though, of course, Ss of $D = 5000$ msec. eventually ceased, it was not until after adaptation had taken place so thoroughly that Os almost never experienced pickup when it finally occurred, in fact, Os usually began to respond before S offset and they almost never realized they had done so. The on- and off-skin movement results for individual Os are presented in Figs. 19 and 20, respectively. It is interesting to note that individual off-skin curves, like those for $D = 150$ msec. bear certain similarities to each other and they are also somewhat similar in shape to the $D = 150$ msec. off-skin curves.

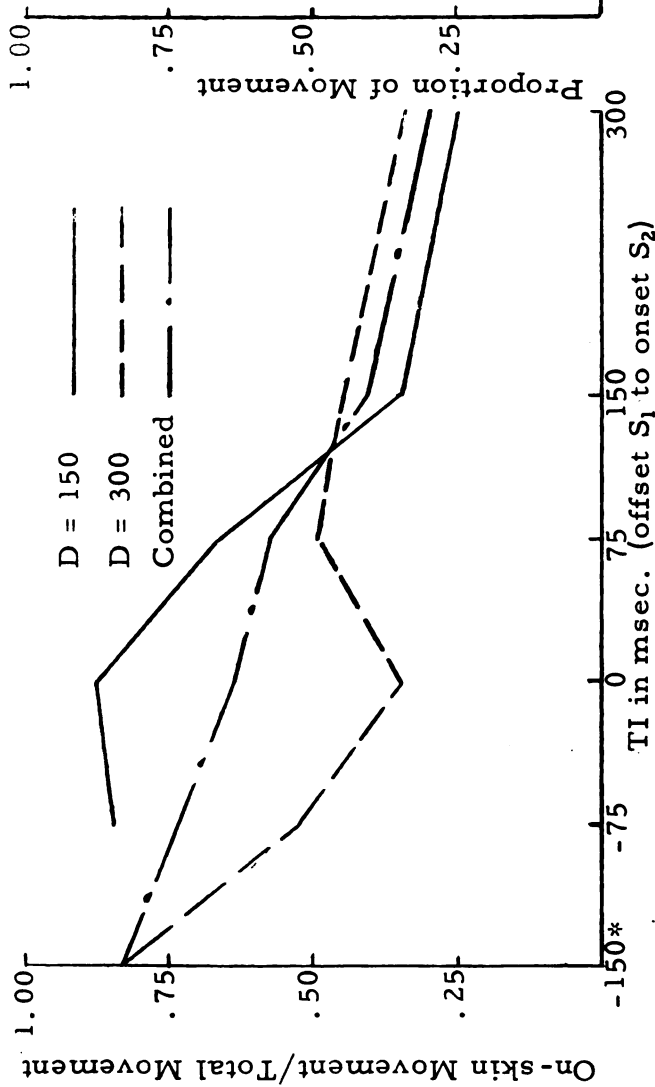


Fig. 17. Proportion of Movement that is On-skin Movement as a Function of TI for D=150 and 300 msec. Conditions.

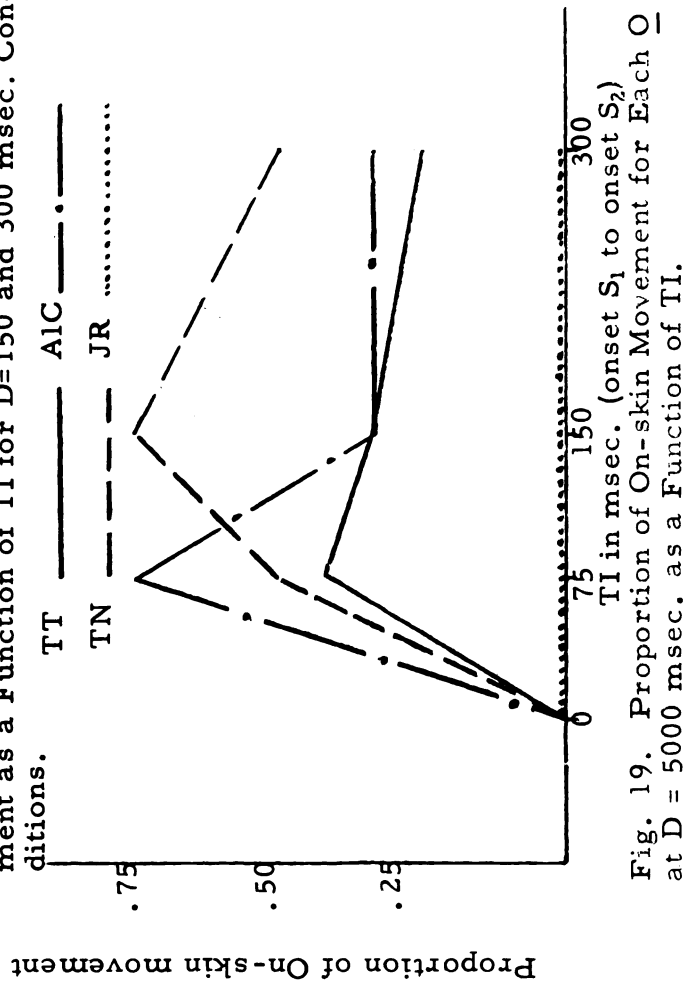


Fig. 19. Proportion of On-skin Movement for Each Q at D = 5000 msec. as a Function of TI.

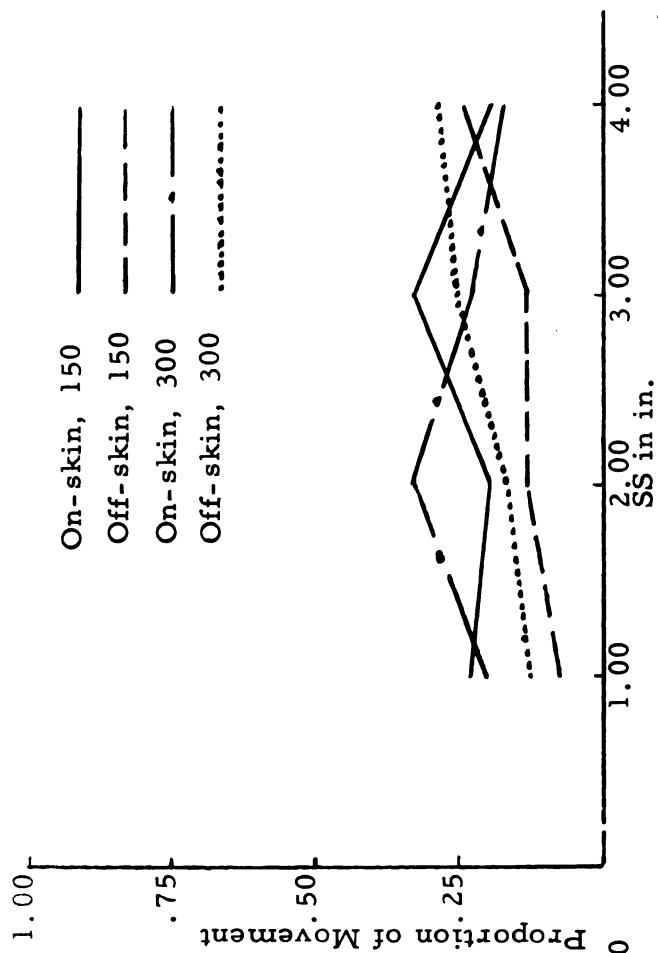


Fig. 18. Proportion of On- and Off-skin Movement at D=150 and 300 msec. as a Function of SS.

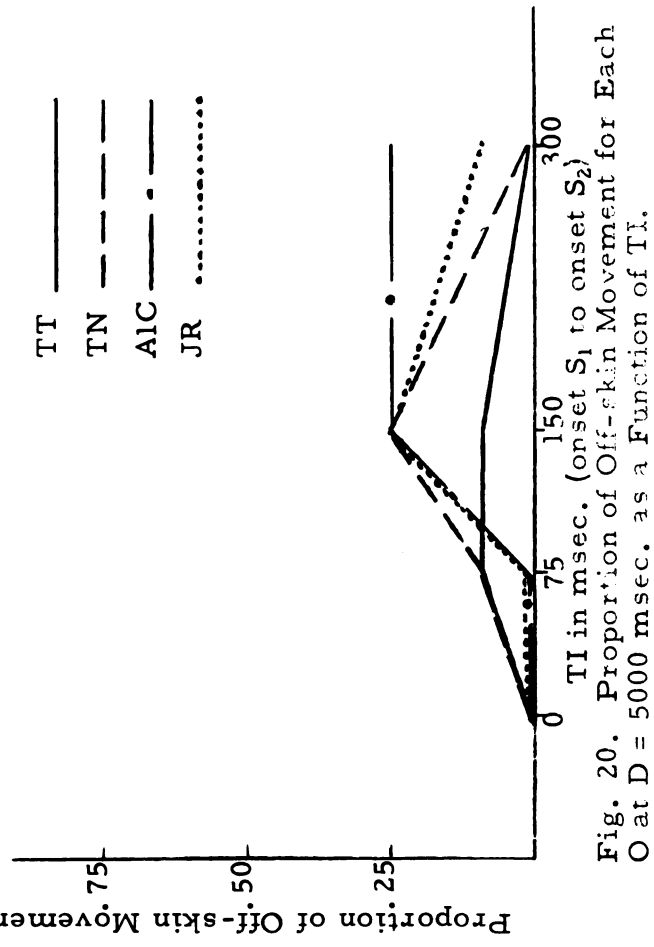


Fig. 20. Proportion of Off-skin Movement for Each Q at D = 5000 msec. as a Function of TI.

6. Experience of pickup of stimulating objects. It was predicted that in order for off-skin movement to occur, experience of pickup or departure of the stimulating object must also occur. To test this hypothesis, the proportion of movement responses occurring in conjunction with reports of pickup were found for each O. All three trials for each condition were not counted in the determination of these proportions, since they probably were not independent. Instead, the mode response regarding both presence or absence of off-skin movement and pickup and non-pickup for each condition was found. Os occasionally reported different pickup experiences for the two styli; when this was the case the experience reported for the first stylus was used in this analysis since it was of principal importance. Results of the 56 conditions exclusive of the one-point, simultaneous, and 5.00 in. S conditions were used in this analysis. The proportions of off-skin movement responses accompanied by the experience of pickup (either fast or slow) were .57, .86, .78 and 1.00 for TT, TN, AlC, and JR, respectively. The combined proportion was .87. In testing the null hypothesis that $p \leq .5$, a $t = 7.11$, $df = 41$, $p < .01$, was obtained, so the proportion of movement with pickup was significantly greater than .5 or chance. The same test was made for on-skin movement. The proportions of on-skin movement with pickup were .52, .80, .78, and 1.00 for TT, TN, AlC, and JR, respectively, and the combined $p = .75$. A $p = .75$ was also significantly greater than .5 ($t = 4.46$, $df = 59$, $p < .01$) so that both on- and off-skin movement occurred a significantly greater number of times with experience of pickup than would be expected by chance. Experience of pickup may, then, enhance the probability of the occurrence of apparent tactual movement. It is certainly not a sufficient condition for its occurrence; of the 53 cases in which the 4 Os reported experience of pickup, 47% of these were not accompanied by reports of movement.

One-point stimulations. Os' reports of pickup for the one-point stimulations are summarized in Table 4. Since the shorter the D, the greater the experience of pickup, one might expect that less movement would occur at the longer Ds. Reference to Table 1 indicates that this supposition is not correct. (Table 1 gives movement for two-point conditions, of course; only two or three spurious reports of movement were obtained with one-point Ss. Frequency of experience of pickup for two-point Ss was approximately the same for D = 150 and 300, and was much less for D = 5000 msec. [Thirty-five, 39 and 7 were the respective frequencies]. Os TN and JR do show a drop in apparent movement at D = 5000 msec., but it must be remembered that the TIs for D = 5000 were not altogether comparable to those of the other two durations, and therefore, it may be that amount of movement at D = 5000 msec. cannot be justifiably compared with amounts at D = 150 and 300 msec.).

Table 4. Perceived Nature of the Departure of the Stimulating Object for One-point Ss of D = 150, 300 and 5000 msec.

D	Nature of Departure (Percent Reported)			
	FP	SP	NP	?
150	42	25	29	4
300	12	33	29	25
5000	12	4	71	12

Verbal responses. The group verbal response curves for total, on-skin, and off-skin proportions of movement for D = 150, 300 and 5000 msec. were highly similar in shapes to their respective experimental curves. There was, however, more movement reported during the experimental sessions, especially off-skin movement, for D = 150 and 300 msec. There was 63% agreement for general classification of

impressions, i. e., A, B, and C (Appendix A) between Os' verbal (practice sessions) and multiple choice (experimental sessions) responses.

Results of conditions in which TI = onset S_1 to onset S_2 interval.

Each of the 4 Os who received the additional 28 conditions reported that he or she had no trouble resuming experimentation without additional practice trials, even after the long interim between experimental sessions 6 and 7. None had any questions about the use of the response key, and only the usual questions about the recording of their responses were asked. The results of all two-point S conditions with TIs indicative of onset to onset intervals are presented in Figs. 21-28. (For $D = 300$ msec., $TI = 0$ msec. conditions, the proportions were assumed to be .00 and were so represented, but since no such conditions were presented to Os, these are only theoretical proportions.) These results, recall, were obtained from the original experimental session conditions after the TIs were converted from offset-onset to onset-onset temporal separations and from the 28 supplementary onset to onset conditions. By combining the two sets of results, it was possible to compare duration curves at 8 onset-onset TIs, ranging from 0 to 600 msec.

In Fig. 21, the proportions of on-skin movement for all Os combined as a function of TI, for each of the three separate durations, are presented. As can be seen, with TI given in terms of onset-onset, the proportion of on-skin movement is very nearly the same across TI for the three S durations. It would appear that amount of on-skin movement for Os combined was not appreciably altered by variations in S duration. After $TI = 0$ (simultaneity), a general decrease in on-skin movement as a function of TI is seen for all three durations. Although a general increase in movement occurred up to about $TI = 375$ for all D s as a function of TI (Fig. 22), the off-skin curves are less similar than the on-skin curves. From $TI = 300$ to 600 msec., the $D = 150$ and 5000 msec.

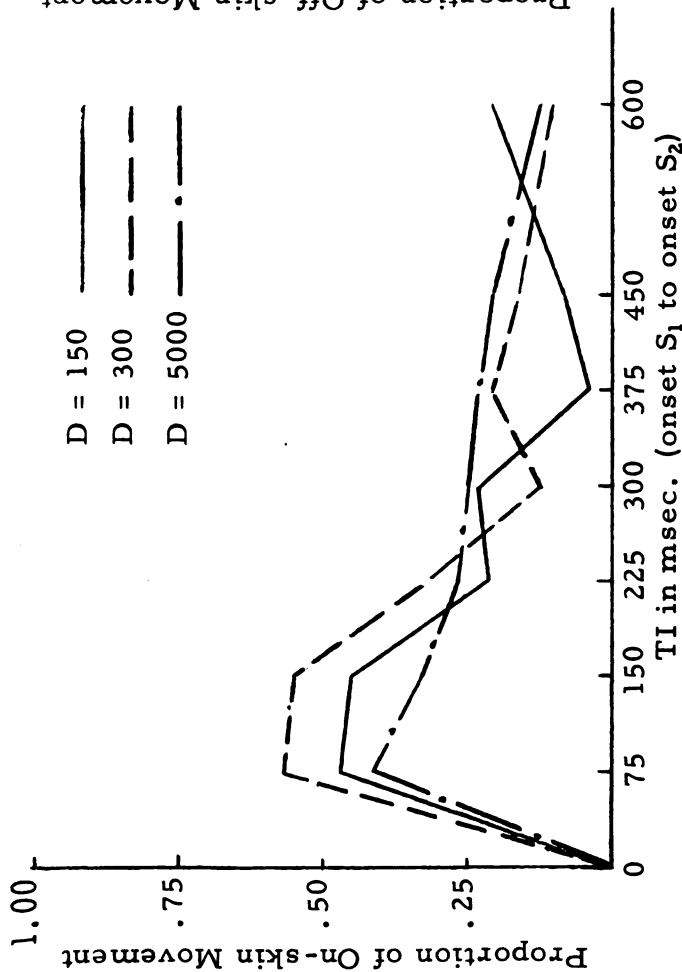


Fig. 21. Proportion of On-skin Movement as a Function of TI for $D = 150, 300$, and 5000 msec. Conditions.

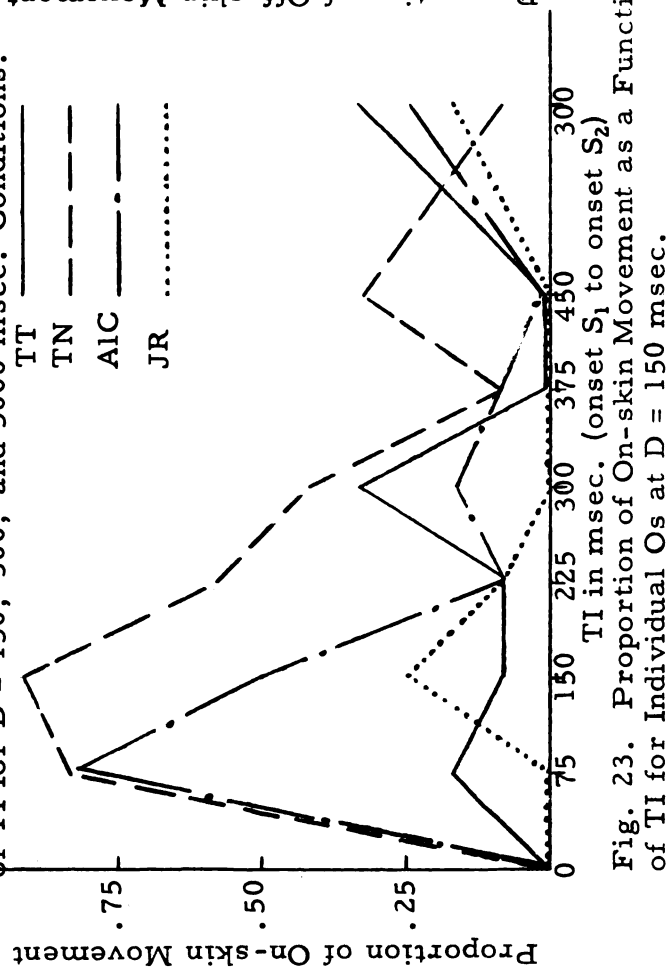


Fig. 23. Proportion of On-skin Movement as a Function of TI for Individual Os at $D = 150$ msec.

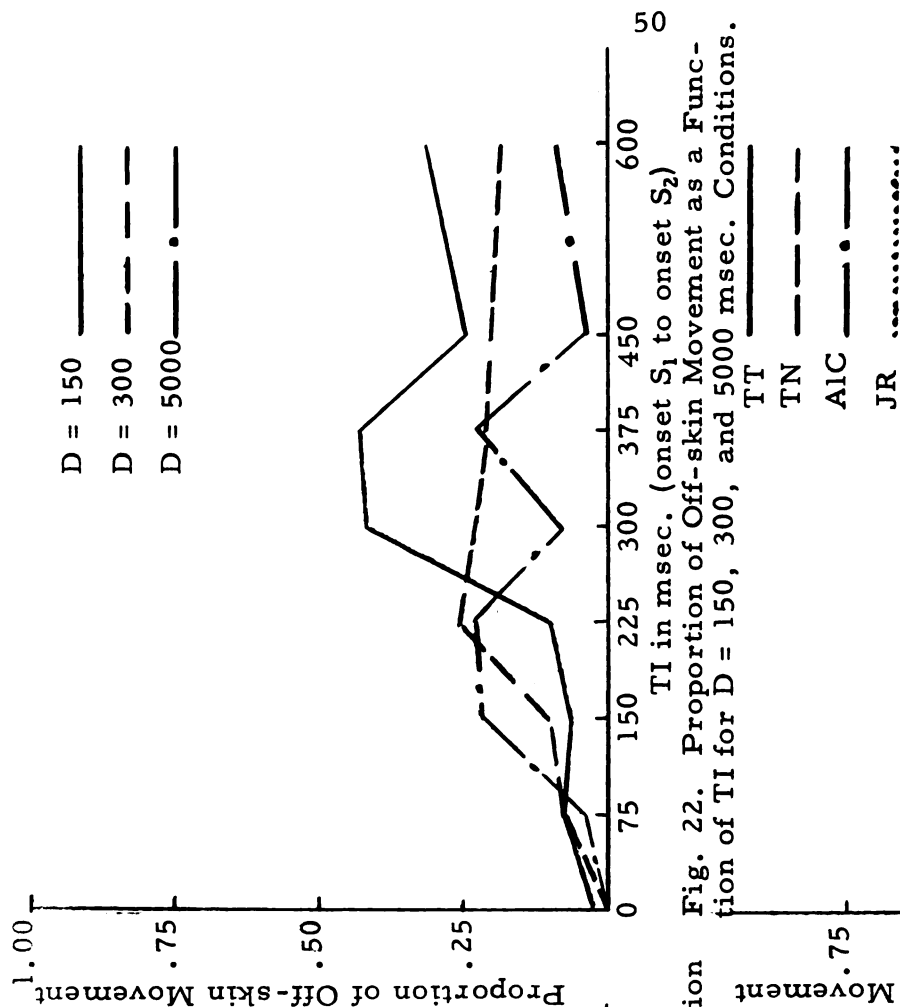


Fig. 22. Proportion of Off-skin Movement as a Function of TI for $D = 150, 300$, and 5000 msec. Conditions.

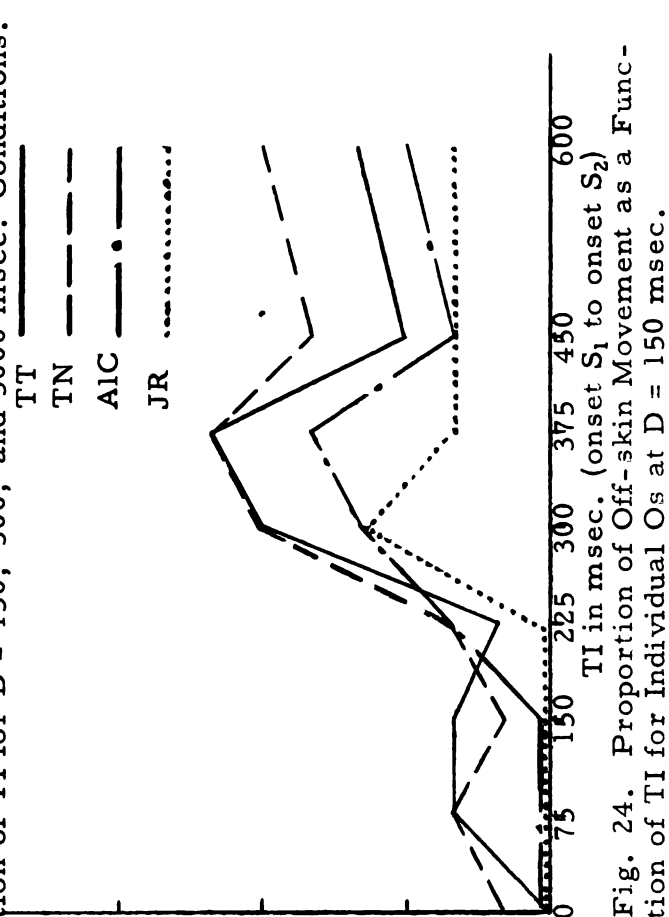


Fig. 24. Proportion of Off-skin Movement as a Function of TI for Individual Os at $D = 150$ msec.

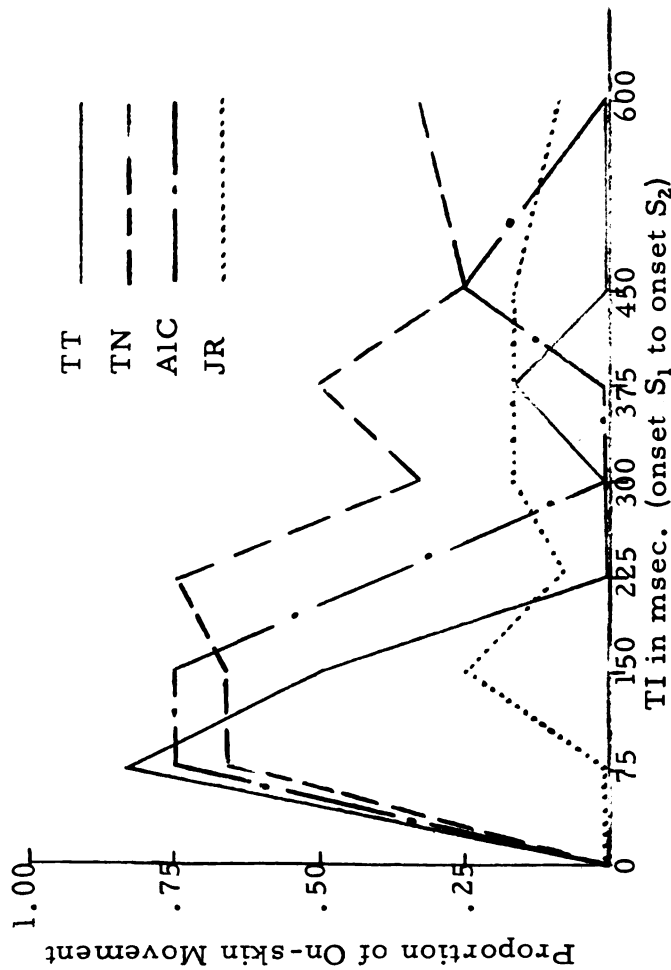


Fig. 25. Proportion of On-skin Movement as a Function of TI for Individual $\bar{O}_s$ at $D = 300$ msec.

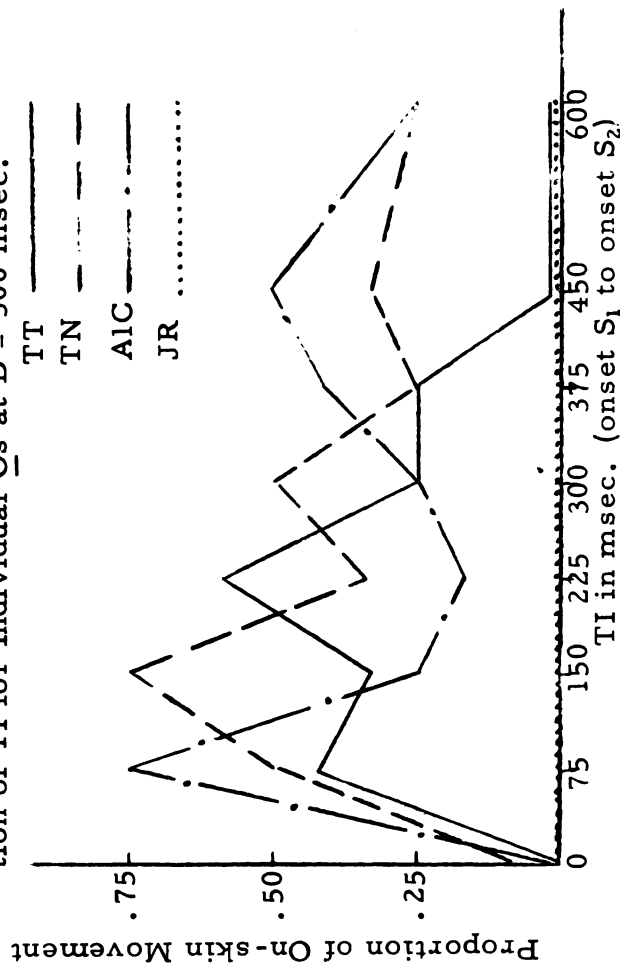


Fig. 27. Proportion of On-skin Movement as a Function of TI for Individual $\bar{O}_s$ at $D = 5000$ msec.

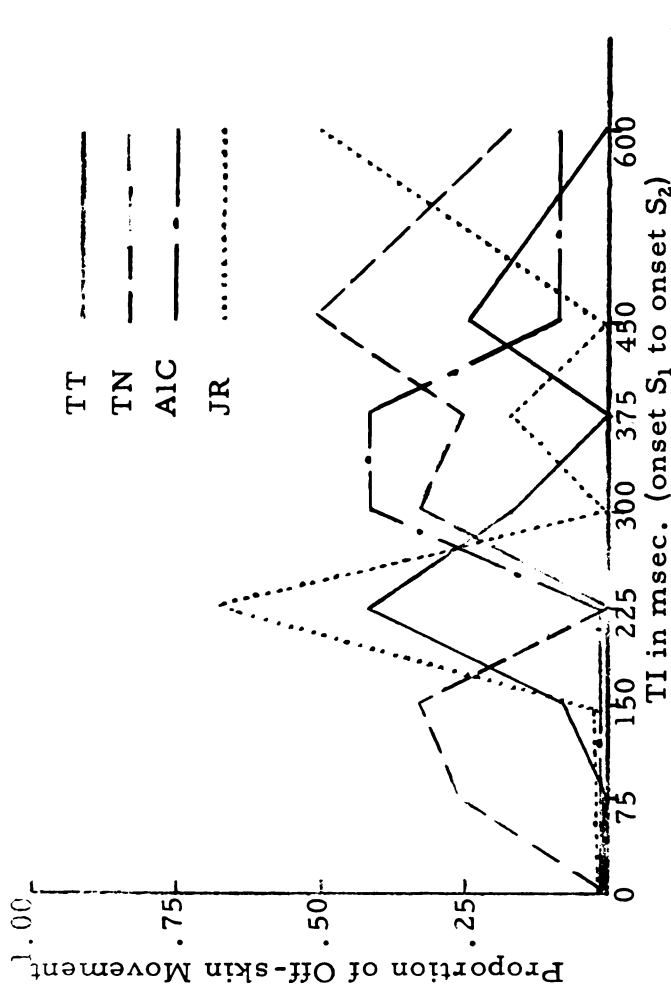


Fig. 26. Proportion of Off-skin Movement as a Function of TI for Individual $\bar{O}_s$ at $D = 300$ msec.

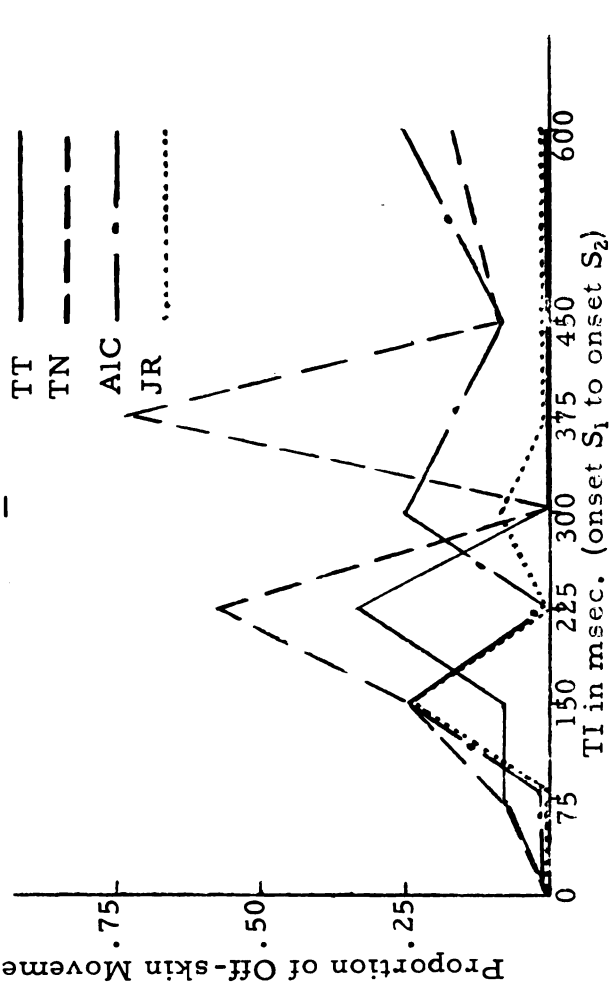


Fig. 28. Proportion of Off-skin Movement as a Function of TI for Individual $\bar{O}_s$ at $D = 5000$ msec.

curves are quite similar in shape, while the $D = 300$ msec. curve is rather different from the former two.

It is imperative to note here that none of the TIs from 300 to 600 for $D = 300$ were presented in the two supplementary experimental sessions, while for $D = 150$, two of them were presented (and these were the only two $D = 150$ conditions presented at the later time) and for $D = 5000$, 3 of the 4 supplementary TIs were in this range. Since, as stated before, the purpose of the experiment was discussed with Os at the conclusion of their 14 original session, and particularly since on- and off-skin movement was specifically discussed, it unfortunately, appears likely that Os' frame of reference had changed or shifted from the early to the later sessions or that they did not have any workable frame of reference for making judgments to the last 28 conditions. (For the first 73 conditions they did, presumably, because they had already encountered all of these 73 conditions in the practice sessions.) It appears that, perhaps because of suggestibility, Os were more prone to experience movement in the last two experimental sessions than in the first six, and since off-skin movement is believed to be far more dependent on broad cognitive references than is on-skin movement, it is particularly with off-skin movement that the increase is seen. A specific case in point is the following: The $D = 150$ on- and off-skin curves of Figs. 21 and 22 are broken down by O and these resulting individual O curves for $D = 150$ are presented in Figs. 23 and 24. Upon examination of the off-skin curves (Fig. 25) the male O curves, i.e. those of TT, TN, and AlC, it can be seen that the proportions at both TI = 375 and 600 exceeds that obtained at TI = 450. It is curious, indeed, that it was TIs of 375 and 600, for $D = 150$ conditions which were presented in the follow-up sessions. The off-skin curves for TT and TN at $D = 5000$ (Fig. 28) show the same effect. While it is possible that these increased proportions are representative of the "true" state of affairs at these TIs, I do not believe it likely.

The obtained proportions of on- and off-skin movement for individual Os for $D = 300$ msec. conditions are presented in Figs. 25 and 26, and for $D = 5000$ msec. conditions, in Figs. 27 and 28. Only the off-skin curves at $D = 150$ are consistent in shape for the 4 Os; and it is interesting to note here that JR's curve is the most atypical of the four, and JR is the only female of the four. (This was also true in comparing other sets of individual curves, for example as seen in Fig. 19.)

In view of the aforementioned effect which seems to have been manifest during the two supplementary sessions, I believe it is unwise to further combine the results from these sessions with those of the previous sessions. However, it is possible to examine, separately, the results obtained from the two supplementary sessions, for although the absolute amount of movement reported was greater (at least for 3 Os) than the previous sessions, within these two sessions the relative proportions of movement obtained for the various S conditions can be contrasted. It was especially hoped that an examination of these results would suggest more completely in what manner SS is related to frequency of on- and off-skin movement. The results of the 7 D and TI combinations at each of the 4 SSs for the 4 Os combined are graphically presented in Fig. 29. As before, the proportion of on-skin movement remained fairly constant as SS was increased from 1.00 to 4.00 in., while off-skin movement increased, rather abruptly at 2.00 in. and to a lesser extent at 4.00 in. Only at $SS = 1.00$ is the proportion of on-skin movement greatly different from proportion of off-skin movement, however.

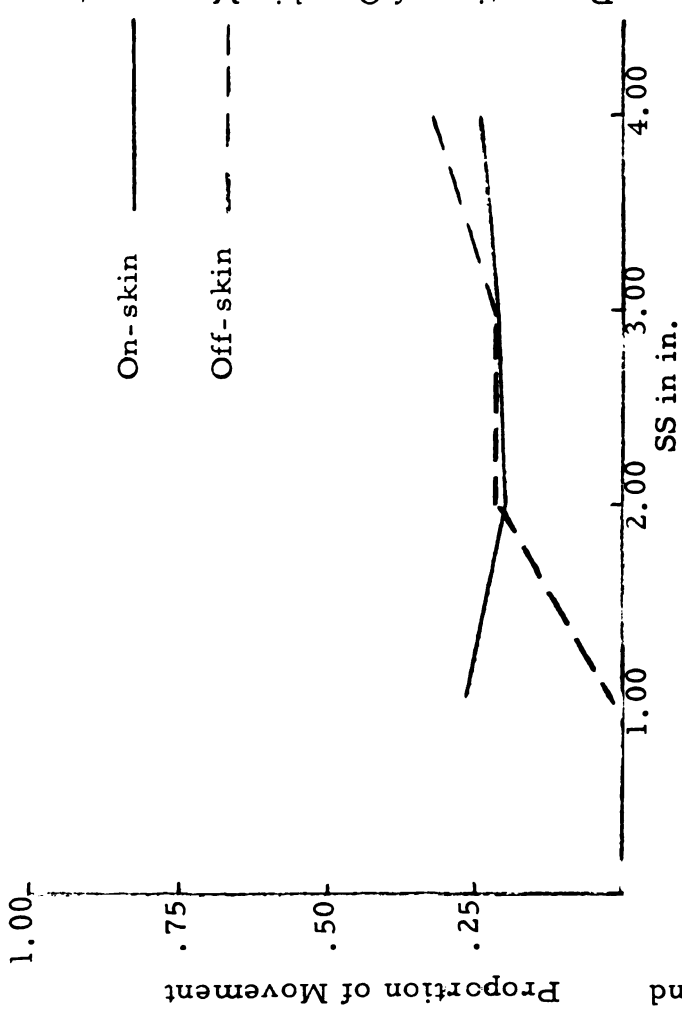


Fig. 29. Proportion of On- and Off-skin Movement as a Function of SS for all $\bar{Q}$ s at all Supplementary S Conditions.

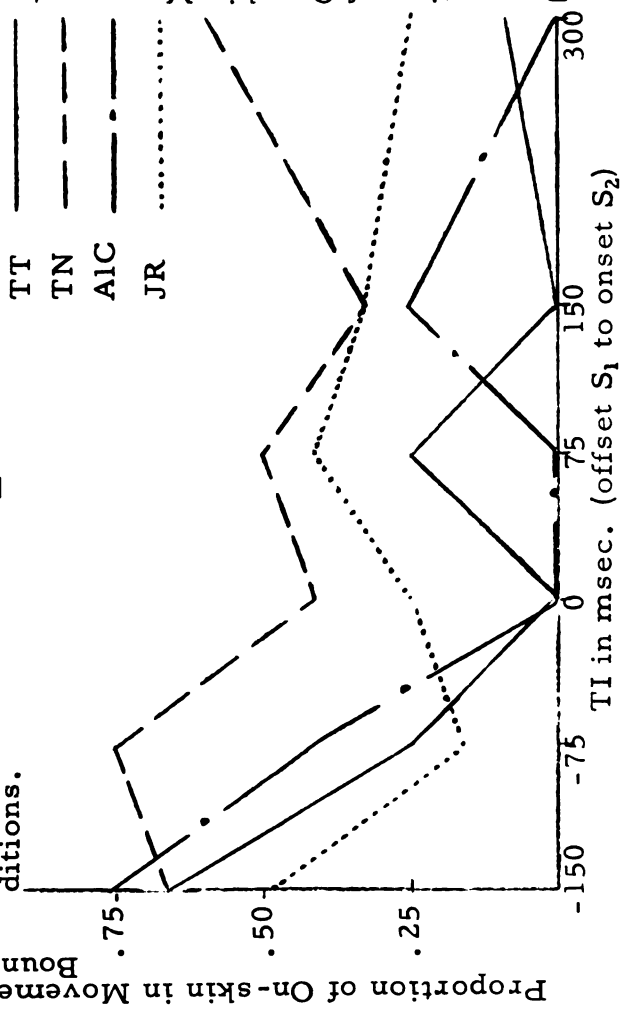


Fig. 31. Proportion of On-skin Movement and Bouncing for Each $\bar{Q}$ at $D = 300$ msec. as a Function of TI.

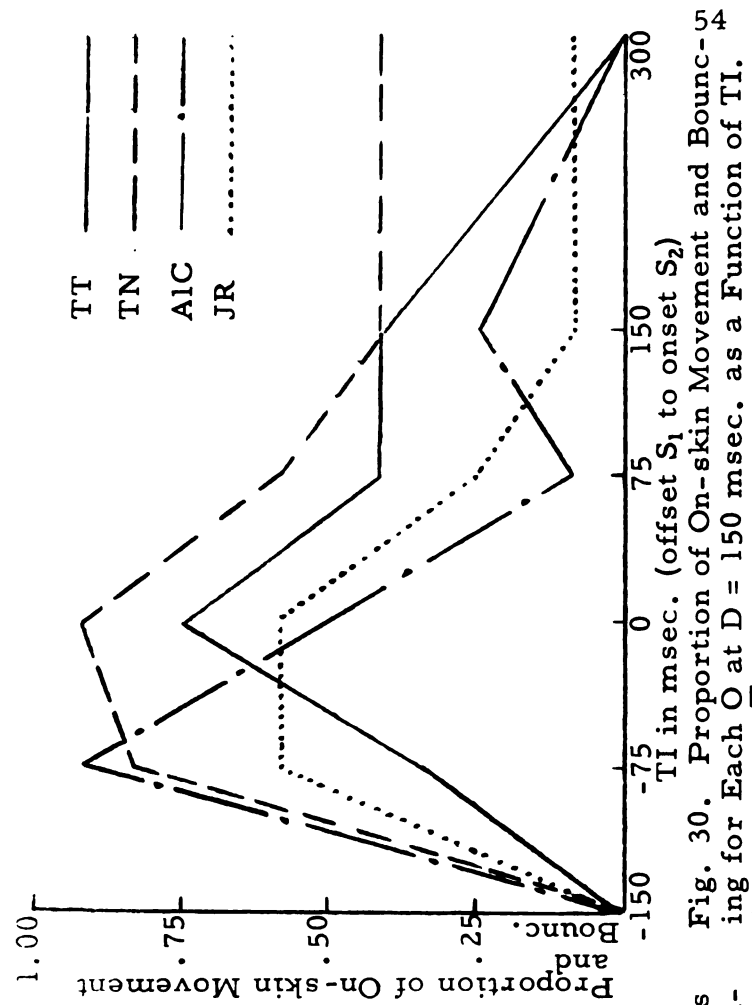


Fig. 30. Proportion of On-skin Movement and Bouncing for Each $\bar{Q}$ at $D = 150$ msec. as a Function of TI.

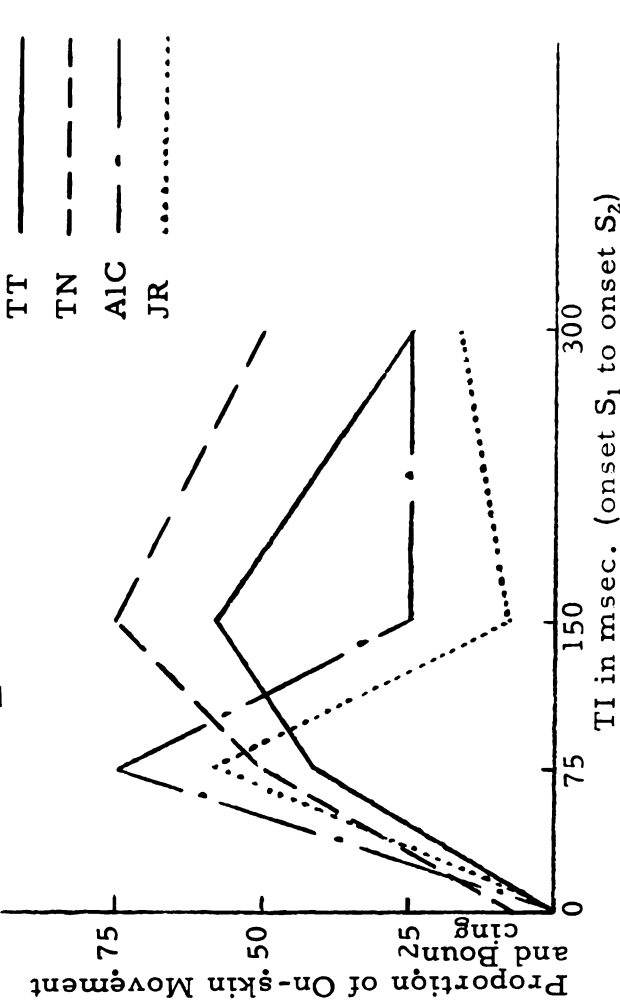


Fig. 32. Proportion of On-skin Movement and Bouncing for Each $\bar{Q}$ at $D = 5000$ msec. as a Function of TI.

CHAPTER V

DISCUSSION

While it is evident from the presentation of results that only qualified support for some of the experimental hypotheses, specifically hypotheses 1, 3, and 4, was obtained it is, nevertheless, possible to identify several important relations pertaining to features of apparent tactual movement phenomena with which these hypotheses were concerned. It is well to emphasize again that these phenomena often seem unreal and transitory, making meaningful response criteria difficult to achieve since referents for these experiences are lacking, and that they are highly subject to set, attitude and day-by-day variations in mood, comfort, fatigue, boredom and physical state. Therefore, inter- and intra-observer variations are to be expected, and thus it is difficult for possible lawful relations between S conditions and movement experiences to be made manifest. All Os at various occasions during the course of the experiment expressed concern about the accuracy of their responses for reasons variously given as inability to concentrate, tiredness, and vague feelings of uncertainty about their experiences. Suggestions for controlling for the effects of such subjective factors are made at the conclusion of this chapter.

The results pertaining to hypotheses 1, 3, and 4 as well as of 2, 5, and 6 will be discussed in order, after which the results in general, along with alternative hypotheses and suggestions and implications for further research, will be discussed.

Hypothesis 1. As shown in Fig. 3, only at the large time intervals does SS appear to function jointly with TI in the determination of amount

of apparent movement in the manner predicted. At the shorter intervals, i.e., from $TI = -150$ to 75 , amount of movement did not vary appreciably for the 4 SSs, but for each SS declined as a function of TI (except at $SS = 1.00$, $TI = -150$). As will be evident in the discussions of on- and off-skin movement, this was due to the fact that off-skin movement, which occurred predominately at the larger TIs as predicted, was dependent on the magnitude of both TI and SS, while amount of on-skin movement, which, as predicted, was inversely related to TI, was not but was dependent only on TI. By combining on- and off-skin movement for the purposes of analyzing total amount of movement as a function of Ss, two different relations of S conditions to frequency of movement are then operative in the resultant combined data. So as not to obscure the two different relations, it would be well to consider on- and off-skin movement only separately and not combined.

Hypothesis 2. The results obtained are in accord with the hypothesis that D need not be inversely related to TI in order to obtain maximal apparent movement (cf. Figs. 4, 7, 13, 21 and 22). This is particularly true of on-skin movement as shown in Fig. 21. The relations between on-skin movement and TI are very nearly the same for the three durations used in this study, including $D = 5000$ msec. For all Ds, the highest proportion of on-skin movement was obtained with TI (onset S_1 -onset S_2) = 75 msec. S conditions, and a decreasing proportion of on-skin movement was obtained thereafter. These results are in agreement with those reported by some of the early researchers. Burtt (1917) reported maximal movement (of all types) at $TI = 75$, Whitchurch (1921) reported the greatest amount of on-skin movement (although she did not call it that) between 50 and 100 msec., and Hulin (1927) found that all types of movement combined and full movement alone (diagram C 8 in the key used in the present study, cf. Appendix A) occurred most frequently at TI (offset-onset) = -75 which is equivalent to TI (onset-onset) = 75 since Hulin used only

D = 150 msec. conditions. In each of these early reports, movement also decreased continually as a function of TI after the peak frequency was reached.

Because only for onset-onset TI conditions can all three durations be compared across TI, it is difficult to determine from the results of the present study, how off-skin movement, for all three durations, is related to TI, due to the inadvisability of combining the supplementary data with the initial experimental data, especially with regard to off-skin movement. (It should also be recalled that two presentations of S conditions of D = 150 and 300 msec. were presented per trial and only one of D = 5000 msec. And the inter-trial intervals for D = 150 msec. were one-half those for D = 300 conditions since the same pawls were used to present conditions of both these durations, which necessitated that for D = 150 msec. conditions the drum speed be twice that of the speed for D = 300 msec. conditions. Consequently, it is difficult to make positive statements regarding the relation of S duration to occurrence of movement.) The off-skin results of this study, given in Fig. 22, indicate that only conditions of D = 150 and 5000 msec., and not of D = 300 msec., are similarly related to incidence of off-skin movement. However, it remains for future experimentation to adequately answer the question of how S duration is related to off-skin (and possibly on-skin) movement.

Hypothesis 3. A comparison of Fig. 6 with Fig. 5, which contain, respectively, the obtained and theoretical proportions of on-skin movement as a function of TI with SS as the parameter, suggests only that there is a general decline in on-skin movement as a function of TI for all SS. Only the proportions of on-skin movement obtained for the 4 SSs at TI = -150 msec. are greatly different, but even then, not in the manner predicted. In any event, it appears that the prime factor in the determination of amount of on-skin movement is the temporal interval between

the two Ss, at least for the conditions used in this study. However, it may be that the SSs used in this study were not varied over a wide enough range to permit the possible effects of SS on incidence of on-skin movement to be made evident. Possibly S conditions with $SS = .25, 2.50, 5.00$ and 10.00 in. would produce differing amounts of on-skin movement at the various TIs. Since extent or completeness of on-skin movement was found to be greatly related to the magnitude of SS and in such a way that it declined as a function of SS, it is expected that if SS were continually increased beyond 4.00 in., at some point the incidence of on-skin movement would begin to decline. And it would be interesting to determine whether amount of on-skin movement would increase for SSs decreasing in magnitude from 1.00 in.

An interesting feature of on-skin movement noted in the results obtained is the following: It was supposed before the experiment commenced that differences in the non-neural features of Os' skin would be a relevant factor in the determination of on-skin movement, since it is the movement of this portion of the skin tissue which in turn activates the surrounding neural tissue, which then eventuates in a tactual experience if the rate and amount of movement was sufficiently great. (Bartley gives a clear account of the relative contributions of the two types of tissue in his Principles of Perception, 1958, p. 361.) Since on-skin movement was thought to be heavily dependent on neural activity and off-skin on visual imagery, it, then, was expected that only occurrence of on-skin movement would be influenced by skin quality. It was hoped that by including both males and females in the study, these possible effects would be, in part at least, controlled for since by including both sexes it was felt that a systematic biasing of the on-skin results would not then occur. However, since one female was removed, only one remained, along with the three male Os whose data were analyzed. It might, then, be fruitful to examine the frequency of on-skin movement reported by the various Os.

By reference to Table 1, one can see that proportions of on-skin movement (for all Ds combined) varied greatly among Os, with the following proportions obtained: $TN = .49$, $AlC = .26$, $TT = .15$, and $JR = .08$. (Note also that the amount of off-skin movement was the same for three Os, 6% higher for the fourth.) If I were to rate these 4 Os as to their firmness or lack of pliability of skin tissue, I would rank them precisely in this order. The implication is, in other words, that it may be that degree of pliability of skin texture does influence amount of on-skin movement. The less pliable the skin, the greater the resistance it would offer to the stimulating object and the greater would be the impact of the object. Possibly, then, the greater the impact and, therefore, the greater the volume of tissue moved, the greater the likelihood of on-skin movement. (Nafe and Wagoner (1941b) stated that they thought variations in skin texture would influence rate and amount of movement in this way, but they did not systematically vary skin texture nor did they elaborate further. They used 2 Os, and although their sex was not reported, at least one was male, since the principal author served as O.) This supposition might, then, account for the consistently dissimilar on-skin results among Os at all durations (cf. Figs. 11, 15, and 19) despite the fact that the off-skin results for identical S conditions (except those of $D = 300$ msec.) are not dissimilar (cf. Figs. 12 and 20).

To further investigate this supposition, the author served as O on 5 successive days, each day with a different skin treatment applied to the tested forearm. (Prior to this testing, the author had served as O for approximately two weeks, six hours per week, so was a practiced O.) Eight conditions were chosen semi-randomly from the original $D = 150$ and 300 msec. two-point stimulations, exclusive of 5.00 in. and simultaneous conditions, by another E. O was not aware of which 8 conditions were chosen until the end of the fifth session, except that E was told to be sure and include some conditions with overlapping stimulations since these

are particularly conducive of on-skin movement and to choose all other conditions randomly. Prior to experimentation on the first day, an ice pack was applied to O's arm, and on the second day a 100 W. lamp was placed on the arm, in each case until the applications became quite unpleasant. (This was done to test the hypothesis that more movement would occur with the heated than with the chilled arm.) On day 3, facial cleansing cream, which is quite oily and can be worked into the skin, was liberally applied to the arm three hours before testing. It was supposed, of course, that by so doing, the pliability of O's skin would be increased. Although it was difficult to achieve a skin condition of low pliability since O, being a female and never engaged in extreme physical activity, had rather pliable skin to begin with, but it was found that by scouring the arm several times before testing with a gritty scouring powder, the skin became much more taut and rigid (probably because of its drying out), and, therefore, less pliable. Testing after scouring was done on the 4th day, and on the 5th day, O was tested under normal skin conditions. The proportions of on-skin movement obtained for the 5 days were, in order, .14, .25, .21, .33, and .29. It is, of course, impossible to ascertain whether these variations were the usual day-by-day variations either partly or completely or whether they were truly the result of the variations in skin texture, but they are in the predicted directions. There was 11% more on-skin movement with the hot compared to the cold condition and 12% more movement with the less pliable than the pliable condition.

Hypothesis 4. Fairly good support was obtained for hypothesis 4, as can be seen by contrasting Fig. 8 with Fig. 7. This was true of the results of the $D = 150$ and 300 msec. conditions combined and for the individual O results for $D = 150$ msec. (Fig. 12), but not for the individual O results for $D = 300$ msec. (Fig. 16). Just why there was consistency

of off-skin results among Os at $D = 150$ (and for $D = 5000$ msec. also, cf. Fig. 20) and not at $D = 300$ is not clear. The combined results for Os at $D = 150$ and 300 msec. conditions, shown in Fig. 8, do suggest as predicted that "time and room" is needed to allow for the inference of movement through the air to occur, and that the more of each, the more likely is off-skin movement to occur, at least for the conditions used. The limiting TI and SS conditions are not suggested in this study since, apparently, not extreme enough conditions were included in the range of TI and SS values used. The proportion of movement at $SS = 5.00$ in. is considerably less than at $SS = 4.00$ in. for $TI = 300$ msec., but it is greater than at $S = 3.00$ (which, in itself, is an aberration unaccounted for) so it is difficult to say whether an $SS = 5.00$ in. is "too great" so that the inference of off-skin movement is difficult to make. (Benussi (1917) and Hulin (1927) reported some bow movement at SSs up to 20 cm. and 150 mm., respectively, and TIs (onset S_1 to onset S_2) up to 620 and 450 msec., respectively.)

Hypothesis 5. It is believed that the results of this study unquestionably indicate that, in contradiction to hypothesis 5, apparent tactual movement of the off-skin and on-skin variety can occur in the absence of S offset. (In the phenomenal sense, S ceases, but no re-stimulation of the skin occurs until after 5 sec. and even then it often does not occur, so that an immediate experience of the physical S offset is not possible.) It is necessary, therefore, in future experimentation to consider onset-onset TIs when S conditions are used which are of durations such that complete adaptation takes place while the stimulating objects are still in contact with the skin. One could reasonably concern oneself with either or both onset-onset or offset-onset TIs when experimenting with S conditions short enough to preclude adaptation, since these conditions stimulate continually throughout the duration of S and at S offset.

(Offset S_1 to onset S_2 TIs would indicate how temporally far apart S_2 is from the last effective presence of S_1 .) If both duration extremes are to be presented, as in this study, and it is desired to compare the results of all durations, then TI must be defined in terms of onset to onset.

Hypothesis 6. Off-skin experiences occurred a significantly greater number of times when pick-up was also experienced than when it was not, as was predicted. This was a reasonable prediction in view of the fact that experience of off-skin movement was considered to depend on a visual image of one stimulating object picking up, moving over and touching down again. It is not, however, reasonable that experiences of on-skin movement were also associated, to a significant extent, with experiences of pick-up. This apparent paradox bothered Os too, because during the experimental sessions, in which they were asked to indicate their pick-up impressions, all of them at one time or another stated to the effect that they couldn't understand it, but it (the first stimulating object) seemed to hit with a sharp, concentrated impact and then simultaneously it picked up and moved across the skin toward the second point of impact. (Os also mentioned somewhat less frequently, a similar effect with $D = 5000$ msec. conditions. The stimulating objects were felt to leave but were still felt to be present at the same time; the experience of their presence then gradually diminished, usually after 2 or 3 sec.).

It is not certain, since experience of pick-up was associated with on-skin movement as well as off-skin movement, just why experiences of movement were accompanied by experiences of pick-up at all. Perhaps on-skin movement is also dependent, to some extent, on visual imagery. The experience of off-skin movement is one of visualizing an "up and over" the skin path of the first stimulating object. Perhaps on-skin movement occurs from the visualization of an "up and across or on" the skin path. The latter visualization is not totally illogical, since it would be possible

to make the first stylus follow such a path. (The stylus, by depressing the skin when it falls, comes to rest in this depression. It could lift out of this depression, re-forming the skin, and then be dragged lightly over the surface of the skin.) It may be, however, that movement responses and pick-up responses coincided as they did because they were simply two ways of describing the same experiences. Or perhaps the coincidence was fortuitous.

The results obtained support the view held by the author that on-skin and off-skin movements are generally aroused by different S conditions, and hence the belief that a thorough, meaningful analysis of apparent tactual movement must embody a distinction between these two types of movement is supported. The S conditions which have high on-skin response probabilities have low off-skin probabilities, and vice versa. The likelihood of occurrence of both types of movement is most heavily dependent on the time interval between S_1 and S_2 . On-skin movement most likely occurs at very short TIs, and generally decreases as TI is increased, while off-skin movement occurs infrequently at short TIs and frequently at long TIs. Apparently size of SS is relevant to amount of off-skin but not of on-skin movement, at least for the S values used in this study. It does have definite relevance to the completeness of on-skin movement, however. This was not true for off-skin movement, since a large proportion of off-skin movement responses were C12 responses at all SSs.

The relevance of variations in S duration to either on- or off-skin movement is not apparent. If variations in D are important, they are probably more important for off-skin than on-skin movement.

It was hoped that the results obtained would be such that the involvement of different mechanisms for on-skin and off-skin movement would be clearly indicated. It was supposed that end organ activity was responsible for on-skin movement and visual imagery for off-skin movement. On the basis of the results of this study, there is no reason to question the

latter supposition, but there is some doubt about the former. How does one account for the fact that on-skin as well as off-skin movement occurred more frequently with experiences of pick-up than without such experiences without implying that visual imagery also plays a role in experiences of movement on the skin?

However, the qualitative differences in on-skin movement as a function of SS can be interpreted as strong support for the notion that movement on the skin is determined by the combined effects on the end organs produced by two Ss occurring in close temporal and spatial contiguity. As has been made clear, it is movement of the skin which must necessarily occur if a tactile impression is to be aroused. It is obvious that when an object falls into the skin, tissue is displaced (depressed) directly under the object, and that the tissue surrounding the locus of stimulation, though to a lesser extent, is also displaced, the amount depending, among other things, on the weight of the stimulating object and the resistance offered by the tissue (as Nafe and Wagoner (1941) suggested). The closer the tissue is to the S object, the more it will be displaced and the sooner it will be displaced. And recall that Nafe and Wagoner found that movement per se, while necessary, is not sufficient for arousing tactile sensations, but it must be movement greater than or equal to a certain rate and amount.

A tiny stylus falling into the skin is experienced as a tiny, discrete point, then, because sufficient movement occurs only at the point of contact; the movement in the surrounding tissue does not incite experiences because it is not sufficiently great. Now consider dropping two styli onto the skin in close temporal and spatial succession; the impacts of the two styli would both contribute to the displacement of the tissue intervening between the two points of contact, so that the resultant effect would be that the combined rate and amount of displacement between the two styli would then be made sufficiently great to arouse a tactile impression. (In their verbal responses, Os frequently mentioned, for very short TI and SS

conditions, experiencing a bar or wire diagonally falling or being placed on the skin, and sometimes these seemed to have knobs at the ends.) Obviously, the shorter the SS and TI, the greater the amount of commonality of displaced tissue and therefore, the greater the likelihood of the arousal of tactile impressions between the two stimulated loci. Experience of on-skin movement occurs because the spread of movement of S_1 occurs first, is enhanced by S_2 following closely and quickly, and consequently S_1 seems to move toward S_2 . S_1 seems to move toward S_2 since it occurs first and becomes the dominant of the two. This domination due to primacy might be overcome by making S_2 sufficiently more intense than S_1 , in which case the direction of movement would be reversed. This effect, called delta movement, has been produced visually and auditorially. It would be extremely interesting to know whether it could also be produced tactually.

This conceptualization of the arousal of on-skin skin movement accounts for the on-skin results obtained in this study extremely well. It accounts for the decrement in amount of on-skin movement as a function of TI, and for the dependence of its completeness upon SS (and to a lesser extent, TI). The conceptualization would also account for the similarities in amount of on-skin movement for the three durations used. Since the movement produced by the styli begins to subside rapidly, the critical rate is quickly past and so it does not matter how long the styli remains on the skin as long as they are not again retracted and dropped.

To make the conceptualization of the mechanism of on-skin movement complete, two additional factors must be considered. First of all, it is sometimes the case that the apparent effects produced by the contiguity of the two Ss are not perceived to move; instead, more than two points or bounces (usually 3 or 4) all of which occur in a straight line from point 1 to point 2, are perceived, but as stationary. Apparent effects of this type, represented by diagrams B8-11 in the response key, were

reported by Os in this study, particularly by JR. Such effects should be taken into account here; although not movement phenomena, they are phenomena pertaining to the connectedness of S_1 and S_2 . In Figs. 30, 31, and 32 (cf. p. 54) are presented the proportions of on-skin movement and apparent bouncing responses for each O for $D = 150, 300$, and 5000 msec., respectively. With the addition of the bouncing responses, inter-observer variations for on-skin phenomena are reduced at each duration (Figs. 11, 15, and 19 contain individual curves for on-skin movement alone), although the individual curves at $D = 300$ msec. are still not greatly similar. This would suggest that bouncing is just another manifestation of on-skin apparent effects, and so ought to be included with on-skin movement analyses. One might consider a continuum of connectedness as going, from low to high degree, from bouncing, to inner, to end, to full movement. The fact that JR had such a high relative proportion of bouncing experiences can be accounted for in the same manner as was the fact that she reported a lesser amount of on-skin movement than the other Os, i. e., by the greater pliability of her skin. The total number of bounces reported by Os to the original two-point experimental conditions, in order of their supposed lack of pliability (from high to low), were TN, 6, AlC, 4, TT, 25, and JR, 37.

An additional factor which must be considered obtains from the recent work of von Békésy (1955, 1957, 1959), and Schmid (1961). They were concerned with traveling waves upon the skin and the significance of these on tactile localization and inhibition. Von Békésy found that a mechanically induced wave initiated at point A was experienced only at point A, even when the wave traveled for several cm. (In attempting to account for such precise tactile localization he stated that, ". . . the maximum of the vibration amplitudes is always directly under the tip of the vibrator, and this is the reason why the sensation is localized mainly under the vibrator" (1959, p. 5). This does not indicate sufficient

cognizance of the criticality of the rate and amount of tissue movement.) The work of von Békésy, Schmid, and others has some relevance to the conceptualization of on-skin movement, because they reported that a vibrating S_1 (or even a non-vibrating S_1) can inhibit an S_2 (generally they mean raise the absolute threshold) or facilitate S_2 (lower absolute threshold), depending apparently on intensity and/or TI of S_s . Von Békésy suggested that an inhibitory mechanism improves localization. Schmid, in reviewing pertinent studies to date, stated that the data show that facilitation only occurs with simultaneous S_s when their intensities are not greatly disproportionate, and that inhibition occurs either when the intensities are disproportionate or when TI is very small. (In her study, maximal inhibition was obtained at TI = 1-5 msec. and decreased and was scant at TIs up to 40 msec. She used shocks for S_s ; S_1 was presented on the second digit of the hand, S_2 on either the third or fourth.) None of the conditions necessary for facilitation or inhibition were presented in this study except the simultaneous S conditions, and movement, of course, was not expected or considered at those conditions. Nonetheless, in an account of on-skin apparent effects and in future apparent tactual movement research, these effects should be considered; qualifying statements about TIs and Is conducive of inhibitory and facilitory effects on thresholds should be made because apparent on-skin effects might be expected to be correspondingly inhibited and facilitated, at such TIs and Is. It is interesting to recall here that Whitchurch (1921) and Hulin (1927), who both presented some TIs shorter than 75 msec. (from onset to onset), obtained maximal on-skin movement at TI = 50-100 msec. and 75 msec., respectively, and gradually increasing amounts up to these maximums.

The fact that large variations among O_s in amount of on-skin but not of off-skin movement was obtained also supports the supposition that peripheral or end organ effects are involved in the arousal of on-skin movement (and not in off-skin movement) because of the suspected role

played by quality of skin tissue. This is in accord with the conceptualization given, since styli would displace a greater volume of firm skin tissue than pliable skin tissue. It would be interesting to determine whether on-skin movement varies directly with muscular tonus by having $\underline{O_s}$, while being tactually stimulated, squeeze a hand dynamometer with varying amounts of effort. And the fact that amount of on-skin movement reported by the author varied at all, much less varied in the predicted and accountable directions, when skin conditions were externally manipulated is indicative of the function of end organs in on-skin movement (if one is willing to assume that the inter-day variations obtained were not merely of the order one would normally obtain for a given $\underline{O}$, and that $\underline{O}$, by having complete knowledge of the experiment, did not bias the results in the expected directions).

The results obtained in this study, though equivocal, are nonetheless clearly rich in implications for future research in the area. It would be exceedingly worth-while to test the hypothesis that the degree of pliability or elasticity of skin tissue is related to the proportion of on-skin movement experienced, and that the relation is an inverse one. In the same vein, it would be expected that intensity of S would be related to amount of on-skin movement. All other S variables held constant, it is expected that the greater the intensity of S_s , the greater would be the amount of on-skin movement reported (at least as long as the increase in I is identical for each S). (Naturally I would have to be at least supraliminal and probably would have to be subliminal for pain.) And, as already mentioned, it would be of great interest to know whether delta movement can be obtained tactually by presenting S_2 with greater I than S_1 .

It would be fruitful in future research to present more widely varied SSs and TIs in order to establish whether SS can be a determinant of amount of on-skin movement, what the limiting SSs and TIs are for both on-skin and off-skin movement, and whether inhibitory on-skin effects

are manifested at the predicted S conditions. The possible contribution of S duration to movement experiences might well be more thoroughly and precisely examined. Inter-trial intervals and number of presentations per trial should be the same for all those S conditions which are to be compared.

A further investigation of the pick-up experiences associated with experiences of both on-skin and off-skin movement might clarify the relation or significance of the one to the others. This clarification might be made simpler by having Os report when, in relation to their total impression aroused by S, S seemed to be withdrawn, if withdrawal were experienced, and what happens to S if pick-up is not experienced. It is not certain, however, whether or not Os could make such specific judgments because even in this study, Os reported occasionally that they had difficulty making accurate reports about the perceived departure of S.

Since, as mentioned at the outset of this chapter, many factors can operate to enlarge inter- and intra-observer variations, and particularly since large variations were obtained in this study, it would be very valuable, though time-consuming, in future research to repeat all conditions a number of times for each O on different days, since in this manner effects of such factors might be averaged out for each condition and, therefore, more stable and representative responses might be obtained.

Finally, it is suggested that in order to achieve the greatest possible understanding of apparent on-skin phenomena, one's point of departure in future research should be more complete than simply a consideration of on-skin apparent movement, but should be expanded to include non-moving, on-skin apparent effects as well.

CHAPTER VI

SUMMARY AND CONCLUSIONS

In previous studies concerned with apparent tactual movement, few contributions were made toward an understanding of the phenomena in question and the mechanisms responsible for their arousal; instead, the results obtained by the early workers in the area were contradictory and ambiguous. A multitude of methodological and theoretical shortcomings were seen as the bases for this state of affairs. The purpose of the present study was, by circumventing these shortcomings, to achieve such an understanding. It was believed that an adequate test of each of the following hypotheses was requisite to any complete understanding of apparent tactual movement:

1) Stimulus conditions which satisfy the direct relation of TI and SS, particularly at the extreme TIs and SSs, are the conditions most favorable for producing movement.

2) To secure maximum frequencies of apparent movement, it is not necessary that conditions in which D is inversely related to TI be used.

3) Frequency of on-skin movement is inversely related to TI and SS jointly, suggesting that temporal and possibly spatial summation of neural activity from the two stimuli is necessary for the experience of movement on the skin.

4) Frequency of off-skin movement is directly related to TI and SS jointly, indicating that "time and room" is needed to make it feasible or logical to obtain movement through the air.

5) Cessation of S must occur (apparently before adaptation is completed) so that both S onset and S offset can be experienced in order for apparent movement phenomena to occur.

6) An awareness of the departure of the stimulating objects from the skin is necessary for the experience of off-skin movement.

Five Os, 3 males and 2 females (one of whom was not included in the data analyses since she failed to report apparent tactual movement experiences) were used in this study for one-hour periods on 14 separate days. A Bartley kinohapt was used to present one- and two-point stimulations to the volar surface of the forearm. A drum, revolving at constant speeds, upon which pawls were secured was used to achieve the desired time intervals (TIs) and durations (Ds) of Ss. The styli of the kinohapt were released by activation of the solenoids, which in turn were activated by microswitches that were tripped by the pawls. The spatial separations between Ss (SSs) were varied by moving the styli the appropriate distances apart.

In S conditions presented in this study, TIs (from onset S₁ to onset S₂) ranged from 0-600 msec., Ds were 150, 300 and 5000 msec., and SSs ranged from 1.00 to 5.00 in. In the original study, 73 S conditions were presented in semi-random orders to all Os; in part I of the original study, which constituted the practice stage, all 73 conditions were presented to which Os were asked to verbally describe their experiences, and in part II, these conditions were again presented but Os in this case were instructed to indicate their experiences by choosing diagrams, from a response key given them, which represented their experiences (or by drawing any necessary additional diagrams). A supplementary study was done 6 wks.-2 mos. after the original, using those Os who reported movement in the latter, in which 28 additional S conditions were presented. Os responded to these as they did in part II of the original study. The data obtained in part I, for various reasons, were not deemed suitable for analytical operations; the data which were analyzed and upon which the following conclusions were based, were obtained in part II of the original study and the supplementary study, though primarily in the former.

It is concluded that:

a) While the obtained relation of total amount of movement to TI and SS was only slightly in accord with the predicted relation, it is suggested that it is more fruitful and enlightening to consider, separately, the relations of on-skin and off-skin movement to TI and SS.

b) D need not be inversely related to TI in order to secure maximum frequencies of either on-skin or off-skin movement; D, in fact, is not related to occurrence of on-skin movement and probably not to off-skin movement either.

c) Frequency of on-skin movement is inversely related to TI, and completeness of on-skin movement is inversely related to SS (and to TI in minor degree). Both quantity and quality of on-skin movement are heavily dependent on the degree of pliability of the skin tissue. A conceptualization of the mechanisms involved in on-skin movement is given which accounts for the on-skin movement results obtained, and which greatly favors the notion that these mechanisms are peripheral in nature.

d) Frequency of off-skin movement is directly related to TI and SS jointly for TI sufficiently large. At small TIs, off-skin movement is infrequent, irrespective of the magnitude of SS. Thus, it is concluded that "time and room" is needed to make movement through the air possible and that neither "time" nor "room" alone is sufficient; hence, it is concluded that off-skin movement experiences are the result of the incitement of appropriate visual images.

e) The physical cessation of S is not necessary for the occurrence of apparent tactual movement phenomena.

f) Experiences of on- and off-skin movements are frequently accompanied by experiences of pick-up of the stimulating objects from the skin. It is not entirely obvious why this association was true of on-skin movement as well as of off-skin movement.

It is concluded that because on-skin and off-skin movements are primarily aroused by different S conditions and were believed demonstrated to depend on different mechanisms, a complete understanding of apparent tactual movement cannot be achieved unless a distinction between the two types of movement is maintained.

A number of suggestions for future research in the area were made; these indicate that additional studies in this area will prove to be extremely interesting and enlightening.

REFERENCES

- Andrews, W. A. Haptical illusions of movement. Amer. J. Psychol., 1922, 33, 277-284.
- Bartley, S. H. Principles of perception. New York: Harper, 1958.
- Benussi, V. Kinematohaptische Erscheinungen. Arch. ges. Psychol., 1913, 29, 385-388.
- Benussi, V. Versuche zur Analyse taktil erweckter Scheinbewegungen. Arch. ges. Psychol., 1917, 36, 59-135.
- Burt, H. E. Auditory illusions of movement. J. exp. Psychol., 1917, 2, 63-75.
- Burt, H. E. Tactual illusions of movement. J. exp. Psychol., 1917, 2, 371-385.
- Dimmick, F. L. An experimental study of visual movement and the phi-phenomenon. Amer. J. Psychol., 1920, 31, 317-332.
- Higginson, G. D. The visual apprehension of movement under successive retinal excitations. Amer. J. Psychol., 1926, 37, 63-115.
- Hillebrand, F. Fur Theorie der stroboskopischen Bewegungen. Z. Psychol., 1922, 89, 262-272.
- Hulin, W. S. An experimental study of apparent tactual movement. J. exp. Psychol., 1927, 10, 293-320.
- Jones, E. E., and Bruner, J. S. Expectancy in apparent visual movement. Brit. J. Psychol., 1954, 45, 157-165.
- Judd, C. H. Ueber Raumwahrnehmungen im Gebiete des Tastsinnes. Phil. Stud., 1896, 12, 425-428.
- Kelly, E. L. The effect of previous experience and suggestion on the perception of apparent movement. Psychol. Bull., 1935, 32, 569-570.
- Korte, A. Kinematoskopische Untersuchungen. Z. Psychol., 1915, 72, 193-296.
- Lehmann, H. Wahrnehmungslehre und Scheinbewegung. Zweiter Teil: Wesen und Entstehung der Scheinbewegung im Lichte neuer Versuche. Arch. ges. Psychol., 1939, 102, 375-450.

- Mathieson, Anna. Apparent movement in auditory perception. Psychol. Monog., 1931, 41 (No. 187), 74-131.
- Nafe, J. P. and Wagoner, K. S. The nature of sensory adaptation. J. gen. Psychol., 1941, 25, 295, 321.
- Nafe, J. P., and Wagoner, K. S. The nature of pressure adaptation. J. gen. Psychol., 1941, 25, 323-351.
- Neuhaus, W. Taktile Scheinbewegungen. Arch.ges. Psychol., 1932, 83, 519-563.
- Pieron, H. Remarques sur la perception du mouvement apparent. Année psychol., 1934, 34, 244-248.
- Ryans, D. G. The phi-phenomenon: a fundamental Gestalt. J. gen. Psychol., 1937, 17, 155-161.
- Schaeffer, A. A. Apparent movement in a diffusely stimulated tactile field. J. gen. Psychol., 1939, 20, 91-107.
- Schmid, Ethel. Temporal aspects of cutaneous interaction with two-point electrical stimulation. J. exp. Psychol., 1961, 61, 400-409.
- Schnehage, H. J. Versuche über taktille Scheinbewegung bei variation phänomenaler Bedingungen. Arch. ges. Psychol., 1939, 104, 175-228.
- Scholz, W. Experimentelle Untersuchungen über die phänomenale Grösse von Raumstrecken. Psychol. Forsch., 1925, 5, 219-272.
- Stampfer, S. Die stroboskopischen Scheiben oder optischen Zauberscheiben, der Theorie und wissenschaftliche Anwendung. Jahr. polytech. Instit. (Wien), 1833, 18, 237.
- Toch, H. H., and Ittelson, W. H. The role of past experience in apparent movement: a revaluation. Brit. J. Psychol., 1956, 47, 195-207.
- von Békésy, G. Human skin perception of traveling waves similar to those on the cochlea. J. Acoust. Soc. Amer., 1955, 27, 830-841.
- von Békésy, G. Sensations on the skin similar to directional hearing, beats and harmonics of the ear. J. Acoust. Soc. Amer., 1957, 29, 489-501.
- von Békésy, G. Similarities between hearing and skin sensations. Psychol. Rev., 1959, 66, 1-22.

von Frey, M., and Metzner, S. R. Die Raumschwelle der Haut bei
Successivreizung. Z. Psychol., 1902, 29, 179-180.

Wertheimer, M. Experimentelle Studien über das Sehen von Bewegung.
Z. Psychol., 1912, 61, 161-265.

Whitchurch, Anna K. The illusory perception of movement on the skin.
Amer. J. Psychol., 1921, 32, 472-489.

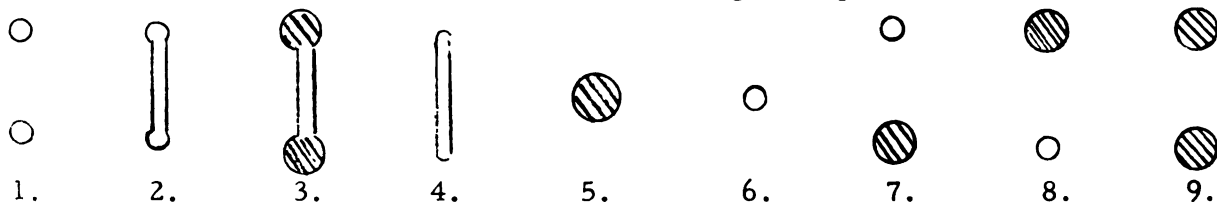
APPENDICES

APPENDIX A: RESPONSE KEY

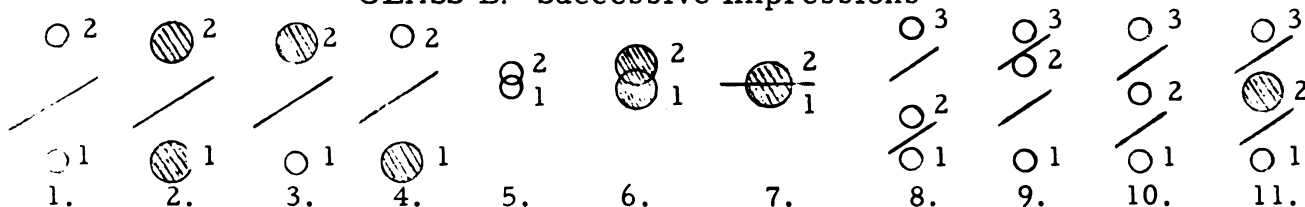
Code:

- represents a single discrete point
- represents a single blunt area (you can allow some variation in the width of such an area)
- ⌋ represents a continuous line or area (you can allow some variations in the width and/or length of these lines)
- ↑ or ↗ represents movement on the surface of the skin (you can allow some variation in the lengths of these arrows)
- ↑ or ↗ represents movement off the skin surface, in the air, and the arrow indicates the direction of movement
- / indicates sequential order

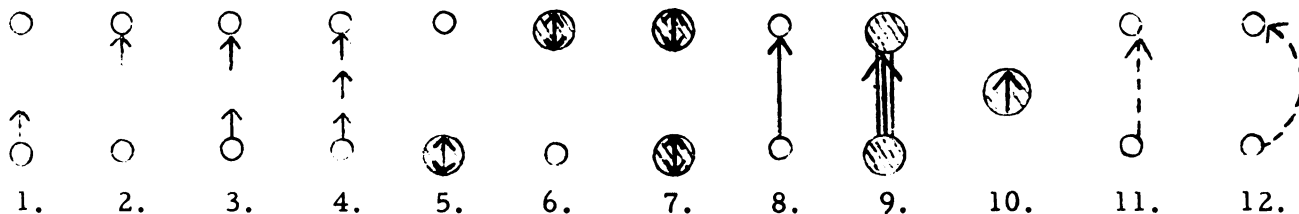
CLASS A: Simultaneous and Single Impression(s)



CLASS B: Successive Impressions



CLASS C: Movement Impressions



Response categories to use in describing the nature of the departure of the stimulating object(s) from the skin:

Response categories

Fast Pick-up
Slow-Pick-up
No Pick-up (stayed down or faded out)
Not Sure

Key (use of data sheet)

FP
SP
NP
?

APPENDIX B: DATA SHEET

Cond.	Trial	Class	Type within a given class	Nature of departure	Space for drawing additional diagrams
1	a.				
	b.				
	c.				
2	a.				
	b.				
	c.				
3	a.				
	b.				
	c.				
4	a.				
	b.				
	c.				
5	a.				
	b.				
	c.				
6	a.				
	b.				
	c.				
7	a.				
	b.				
	c.				
8	a.				
	b.				
	c.				
9	a.				
	b.				
	c.				
10	a.				
	b.				
	c.				
11	a.				
	b.				
	c.				
12	a.				
	b.				
	c.				

ROOM USE ONLY.

~~APR 25 1964~~

APR 25 1964

MICHIGAN STATE UNIVERSITY LIBRARIES



3 1293 03070 9921