KINESTHETIC ABILITY AS RELATED TO A BALL CATCHING TASK WITH DOMINANT AND NON-DOMINANT HANDS

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by

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A THESIS

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ABSTRACT

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Purpose

This study was designed in an attempt to investigate a specific skill pattern as it relates to kinesthetics and hand dominance. The specific skill pattern under investigation was the ability of subjects, using either their dominant or non-dominant hand, to catch a ball when they were unable to see their arm and hand.

Method

The tool developed for this study was an "L" shaped curtain. The front of the curtain contained a circular target hole allowing a thrown ball to pass through. The side of the curtain contained an arm sleeve which allowed the subject to see the ball in it's parabolic flight pattern but did not allow the subject to see either her arm or hand.

One hundred and sixty high school girls were randomly chosen and assigned to one of the following four experimental treatment variables: (1) dominant hand kinesthetic catching ability (2) dominant hand visual catching ability

(3) non-dominant hand kinesthetic catching ability and (4) non-dominant hand visual catching ability. Data was recorded on their ability to catch the ball and on their ability to hit or touch the ball.

Summary and Evaluation

By the use of the F statistic it was found that there was a significant difference between vision and kinesthesis in the ball catching task. A significant difference was also found between dominant and non-dominant hands in the catching task. A further analysis of the data through the use of the t statistic revealed no significant difference between dominant and non-dominant hand catching ability in the visual catching task.

The F statistic was also used to evaluate the data collected on the subject's ability to touch or hit the ball. The results indicated no significant differences between the four experimental treatment variables.

Based on these findings, it appears that subjects do not differ in the spatial orientation of the hand and arm in the visual or kinesthetic ball catching task. However, observing the ball until it hits the hand does seem to be necessary for the temporal orientation of the hand in the catching task. When vision was present, subjects could catch equally well with their dominant or their non-dominant hand. But, it did not appear to be the hitting of the ball on the hand that was the signal for the grasping action.

Veronica L. Eskridge
Supervising Professor

To

My Parents

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

THE PROBLEM

Introduction

Many noted authors of textbooks dealing with kinesthesis have stated that kinesthesis is not a general factor but rather, it is specific to the skill (Oxendine, 1968:293; Sage, 1971:120; Singer, 1968:327; Drowatzky, 1975:183). Thus, the batteries of tests developed to measure kinesthetic ability can be assumed to measure only the kinesthetic ability for that particular test. With this in mind, rather than attempt to develop a general measure on kinesthesis, it seems preferable to test a specific motor skill and make a particular application.

Statement of the Problem

This study was designed in an attempt to investigate the subject's ability to catch a ball when the catching arm was not visible. This ability was observed for both dominant and non-dominant arms and hands.

Need for the Study

There is considerable research available concerned with measuring kinesthetic ability. This research has been concerned with the concept of establishing a general kinesthetic sense. However, to date no single test or battery of tests has been designed which is capable of measuring the general kinesthetic sense (Phillips, 1941:584; Scott, 1955:339; Wiebe, 1954:227; Young, 1945:283). Since the specificity of kinesthesis was established very little research has been conducted which concerns complete, though specific, skill patterns. Thus, the research is limited in its applicability to skills associated with sports and physical education. The few studies which have been done relating to specific sports were attempts to correlate a battery of kinesthetic ability tests to a specific skill (Mumby, 1953; Wettstone, 1938; Witte, 1962). These studies produced low correlations which support the contention that kinesthesis is specific to the skill. Thus, tests are needed which measure the kinesthetic aspects of specific skills. The results from these tests could then be used in ascertaining specific kinesthetic abilities.

Delimitations

The generalizations of this study are delimited to female subjects of large high schools located in major metropolitan areas with a low to low/middle socioeconomic class distribution and a racial composition of White Anglo, Latin American, Black, and Oriental.

The subjects under investigation were enrolled in Girl's Physical Education at MacArthur High School in the Aldine Independent School District, Houston, Texas. There was a racial distribution of approximately fifty percent White Anglo, forty-five percent Latin American, five percent Black, and less than one percent Oriental.

The concept under investigation was visual and kinesthetic ball catching ability with both dominant and non-dominant arms and hands.

Theoretical Hypotheses

Kinesthetic ability, visual ability, dominant hand ability, and non-dominant hand ability as related to ball catching are the factors being analyzed in this study. It is hypothesized that there will be no significant difference between kinesthetic ability and visual ability in the ball catching task. Whiting, who has done much research in ball catching tasks, reports that viewing the ball in its' initial flight would lead to successful catching (Whiting, 1974:32; Whiting, Gill, & Stephenson, 1970:270; Sanderson & Whiting, 1974:87). It is further hypothesized that there will be no significant difference between dominant and non-dominant skill abilities in both the kinesthetic and visual tasks. Glencross and Tyler support this hypothesis in research they have conducted on dominance and preferred hands. They imply that hand preference as related to skill level is the result of practice and experience (Glencross, 1970:230; Tyler, 1971:257). If significant differences do occur an analysis of the subject's ability to spatially orient her hand to the ball will be studied in an attempt to clarify the results.

Null Hypotheses

In order to investigate the theoretical hypotheses discussed above the following null hypotheses were statistically tested:

1. There will be no significant difference between mean dominant hand-visual catching ability scores and mean dominant hand-kinesthetic catching ability scores.

2. There will be no significant difference between mean non-dominant hand-visual catching ability scores and mean non-dominant hand-kinesthetic catching ability scores.

3. There will be no significant difference between mean dominant hand-visual catching ability scores and mean non-dominant hand-visual catching ability scores.

4. There will be no significant difference between mean dominant hand-kinesthetic catching ability scores and mean non-dominant hand-kinesthetic catching ability scores.

Definition of Terms

Ambidextrous. The ability to write comfortably with both hands.

Ball catching ability. The number of catches a subject can successfully execute out of ten trials.

Dominant hand. The hand which is used in writing skills.

Ethnicity. Individuals identified by the experimenter as being of Black, White Anglo, Latin American, or Oriental background.

Kinesthetic ability. The subject's ball catching ability without visual knowledge of the position of the catching hand.

Kinesthesis. "The discrimination of the positions and movements of body parts based on information other than visual, auditory, or verbal" (Sage, 1971:117).

Non-dominant hand. The hand not used in writing skills.

Visual ability. The subject's ball catching ability with visual knowledge of the position of the ball catching hand.

Abbreviations. The abbreviations used most frequently throughout this paper are given in Table I, page 6. Any other abbreviation will be defined in the text.

TABLE I

EXPLANATION OF ABBREVIATIONS USED

Abbreviation	Experimental Treatment Groups Variable Received
NDK	The use of the non-dominant hand in a kinesthetic catching task
DK	The use of the dominant hand in a kinesthetic catching task
NDV	The use of the non-dominant hand in a visual catching task
DV	The use of the dominant hand in a visual catching task

CHAPTER II

REVIEW OF RELATED LITERATURE

Kinesthesis is a topic that has been afforded considerable attention in the literature. However, as Cratty states:

> It is particularly difficult to determine just how these findings from a majority of these studies contribute in applied ways to our understanding of voluntary motor activity. This difficulty of pairing data with practicalities seems to be caused by at least two incongruencies: (1) Most studies of kinesthesis involve rather static, discrete, and usually slowly executed positioning movements; whereas in life situations movements are rapid and flowing. (2) By definition kinesthetic judgements exclude the use of vision, whereas again in the "real world" people seldom consciously exclude vision from their motor experiences (1973:101).

Most studies between static measures of kinesthesis and dynamic movement tests show little or no significance. Roloff's study (1953) designed to measure the relationship between kinesthesis and general motor ability produced a correlation of .43 at the .01 level of significance. Though this is the highest correlation obtained relating kinesthesis to general motor ability it cannot be considered a strong correlation. Thus, as Singer states "There is no general kinesthetic sense. It is specific to the test and the part of the body involved in the skill. Kinesthesis...

must be developed specifically for a particular task" (1968:327).

Smith in reviewing the literature on kinesthesis referred to an article by Rock and Harris (1967) "It is evident that man does not rely extensively on kinesthetic feedback; he tends to be more visually oriented" (1969:40). Thorsheim et.al., concurs with Smith. In a study they did they concluded "Ss will rely predominantly upon visual information if it is readily available with a high degree of precision, while neglecting kinesthetic perception" (1974: 203). They felt that if visual feedback is inherently a more potent variable for motor learning it may be because it provided more precise error information than kinesthetic error information especially if the visual feedback loop is sufficient to maintain the subject's confidence in his performance at a maximum (1974:203). Posner states "when both vision and kinesthesis are available for reproduction, the retention follows the rules of the visual code" (1973:64). Laszlo and Baker support this assumption with certain stipulations. They are of the opinion that visual cues can effectively guide performance in the absence of kinesthetic information but once a subject has learned to rely on visual and kinesthetic cues he cannot perform as accurately when the kinesthetic cues are removed (1972:75). Thus, once the specific sensory modality is practiced and utilized at the conscious level it affects subsequent performance. Alderson et.al., in reviewing a study done by Whiting, Gill, and

Stephenson (1970), made the assumption that subjects under normal viewing conditions were not consciously aware of the temporal prediction component in the ball catching task. However, when placed under restricted viewing conditions the subjects experienced less success, thus, this aspect of prediction became less accurate, attracting the subject's attention to it (1974:218). Attneave and Benson propose "that different modalities have qualitatively different facilities for data handling and that sensory information may be transferred to the modality best able to process and store it" (1969:222).

In examining the neurological bases for kinesthesis Smith postulates that the central nervous system selectively permits sensory stimulation to enter centers subserving perception. Thus, it may be the case that kinesthetic information is inhibited from reaching higher centers. The reticular formation and thalamus are involved in this screening process and this screening control has been demonstrated at all levels of synaptic centers which receive kinesthetic feedback (1968:40). The receptors responsible for the perception of kinesthetic information are located in the joints according to many researchers (Smith, 1969:43; Marteniuk & Roy, 1972:278; Marteniuk & Ryan, 1972:141; Marteniuk, 1973:257; Craske & Crawshaw, 1974:276). However, Jones in a current review of the literature on internal feedback states that joint receptors have been shown to mediate knowledge of passive movements and that the muscle spindles may be responsible for mediating knowledge of force. Muscle spindles may also correct for sudden changes in load on the muscles via peripherial feedback loops and could be responsible for indications that a muscular contraction has occurred or is occurring without specifying the degree of contraction (1974:41). This issue is still a controversial topic of discussion in the literature.

In relation to skilled performance Kay states, "The skilled man can appreciate some events more quickly than the unskilled because they are less uncertain for him; they carry less information" (1957:219). The general concensus of opinion is that kinesthesis is not specifically related to age but upon the amount of information contained and familiarity of the person with the movement (Phillips & Summers, 1954:467; Smith, 1969:39; Millar, 1972:280; Whiting & Cockerill, 1972:160; Adams & Dijkstra, 1966:317). Kay gives an example of this when he states the following, "If we throw a ball for a young child to catch he is invariably too late in positioning his hands and lets the ball hit him on the chest. We say he doesn't anticipate the flight of the ball; he doesn't know where it will go but only where it is" (1957:219). With this example one can assume a correlation between age and skill but one must also remember that the child has had less experience with the skill and is therefore less familiar with the movement. Kay goes on to state,

> Let us imagine the situation is such that our adult subject's head is fixed and he can only observe the trajectory of the ball by successive fixations. Thus we have the trajectory divided into a series of segments, which we might think of as events, a, b, c, and so on. An individual through his experience of watching how objects travel in space learns about the probable order and temporal relations of these events. Thus, given events a, b, c, he predicts the future position; and the skilled person is the one who can predict accurately on the fewest possible initial events. Once this is achieved the remaining events in the series are redundant, or at the most confirmatory. So much for the popular dictum about "keeping your eye on the ball" (1957:219).

Whiting in his book, Acquiring Ball Skill, is in agreement with this statement. According to Whiting, there is presumably nothing which is innate in a person's ability to understand the parabolic flight of a ball (1969:18). This is a process which must be developed through experience and practice. Therefore, the beginner would presumably need to keep his eye on the ball for a longer period of time so as to process information of both spatial and temporal future behavior of the ball before catching it (Whiting, 1969:34). Nessler (1973:184) and Whiting, Gill, and Stephenson (1970:270) have generalized in their studies using college students that watching the ball for longer periods of time led to more successful catching. Sharp and Whiting propose in their study that it is not the time the ball is seen per se that is important when processing flight information but the critical factor is the total time available in processing this information (1974:144). They suggest that the relationship is curvillinear. If the amount of time that the ball is not seen is increased (thereby allowing more processing time) it also increases prediction extent which, as it becomes larger, outweighs the advantage gained by the increase in processing time (1974:146). These statements were also inferred in an earlier study done by Whiting and Sharp (1974:15).

Results from these studies might indicate that this is occurring because of information processing limitations. The shorter the amount of time the ball is seen the less amount of time that is available to process flight information. In a study done by Whiting and Sharp where subjects were not allowed to view the ball until very late, the subjects were unsuccessful in catching the ball. One explanation given was that subjects did not have sufficient time to process the necessary flight information. Also, they may not have time to translate the perception of the ball's flight into an appropriate response pattern (1974:15). However, it has been suggested by Sanderson and Whiting that, "It is possible that exceptional ball game players possess, among other relevant abilities, an oculomotor control enabling them to process ball flight information quickly, even when exposure time is severly limited" (1974:87).

Individual differences must be taken into account when discussing degrees of skill. One individual may perceive more than another because his selective attention is directed to the more relevant cues or information displayed. The less skilled performer either responds to the wrong cues or responds incorrectly to the right ones. The more skilled the individual becomes the more able he is to respond correctly to the more revelant cues (Whiting, Gill, & Stephenson, 1970:256). Once the task becomes coherent it contains redundant and predictable stimulus sequences which are important factors affecting timing and anticipation and, hence, organization and patterning of responses in skilled behavior (Dorfman & Goldstein, 1975:46).

Examining it neurologically, Jones states that fast rates of movements characteristic of high skill level are probably beyond the control of feedback loops from the periphery to higher centers. He presents an argument for the "outflow theory" that implies that the central nervous system may store preprogrammed time responses for movement (1974:34). Support is in the literature for this theory (Gregory, 1966:97; Whiting, 1969:57; Keele & Ellis, 1972:128; Marteniuk & Roy, 1972:472). However, this does not mean to imply that kinesthetic information is not available for fast rates of movement. It is the opinion of Stallings that kinesthetic feedback is effective in the latter stages of learning when movement errors are relatively small. He thinks that kinesthetic information provides terminal feedback in those skills which are too fast to correct during execution (1973:83). Whiting explains preprogramming quite well when he states, "It would seem that initial relatively discrete movements become organized into larger programs of responses probably on the basis of the monitoring of feedback information from external and proprioceptive stimuli. Larger units of response often constitute ballistic actions which become programmed as a whole and it is the timing of their application which is crucial in determing the efficacy of a response" (1969:57-58). He continues by suggesting that an athlete who is highly skilled might be assumed to have in his nervous system a preprogrammed response for a particular complete action (1969:58). The variations of this program may possibly be due to random firing of neurons or they may be due to variations in the level of activation of the athlete (Whiting, 1969:58). Whiting presents one other possible explanation that, "Variations in the execution of the skill are brought about by variations in body orientation of the player and in temporal sequencing of the individual muscular responses which go to make up the total skill-pattern rather than in a modification of the underlying 'plan' of action" (1969:59-60).

The variations of body orientation, and more specifically, limb orientation is a topic currently under discussion in the literature. Much of the research done is in agreement with Cratty in that positioning movements executed without vision are influenced in marked ways by just-prior position of the limbs (1973:90). Craske and Crawshaw noted that the more remote starting position generated the largest limb movement errors (1974:276). They also noted that "a body part maintained in one position for any length of time is subsequently placed nearer to the previously held position than the subject is himself aware" (1974:273). Duffy et.al., found that shorter movements produced more overshooting than longer movements (1975:62). Marteniuk et.al., found that without starting position or end position cues, subjects were significantly less accurate than they were when the cues were present. This suggests that active movement cues as a whole do not provide sufficient information for accurate reproduction of movement. It was assumed that other important cues are derived from the starting and ending position of the movement other than just the position of the limb (1972:55). In a study presented later that year, Marteniuk and Roy obtained results that were a direct contradiction to the earlier study in that they found that the limb can accurately reach the same location in space regardless of the initial starting point (1972:478). In a cinematographic study of ball catching using two different limb starting positions it was found that the hand passed through positions very similar to one another while executing the catching task (Alderson, Sully,

& Sully, 1974:222). Studies of this nature add support to the fact that the motor system, in producing a motor response, is very flexible and can arrive at the same end result from a variety of different initial locations. However, in the cinematographic study, the subjects were skilled ball game players which may imply that this is a characteristic of the highly skilled.

It would, therefore, seem possible that skilled players can learn and store the relative prediction of even complex ball flights and come to make their contact predictions from very early cues and at times almost before the ball is released (Whiting, 1969:19; Whiting and Hutt, 1972:96). Nessler states that the experienced tennis player is thought to take his eyes off the ball after it has hit the opponent's racket to make a strategy decision regarding the most desirable return shot (1973:179). Kay refers to the skilled athlete as having all the time in the world (1957:219). Whiting states that as skill improves, the player knows where the hand(s) or implement is without looking (1969:56).

Whiting and Cockerill also infer that viewing the target (ball) yields greater accuracy than looking at the hand (1974:32). The beginner will characteristically attempt to hold the arms so that they can be sighted in relation to the ball in flight. But, as the player becomes more experienced, such information becomes redundant and the catching task is brought about purely on the basis of proprioception (Whiting, 1969:56).

Practice and skill in one hand catching is, when applied to physical education and recreational programs, usually developed by playing softball and baseball. Thus, through the use of a glove, the non-dominant hand is used in catching skills. This would seem to indicate that in one hand catching ability the non-dominant hand may perform more accurately or equally well to that of the dominant hand although no specific evidence has been found to support this assumption. Glencross thinks that timing and hand preference, as related to skill level, is the result of differential practice and experience (1970:230). Tyler states that, "if dominance is a factor in motor skill acquisition, this is an experimental phenomenon which can be modified through practice" (1971:257). However, Cratty supports the idea that preferred hands and legs move more accurately in placement than non-preferred limbs (1973:101). Studies not related to a catching task indicate the preferred arm performed better than the non-preferred arm (Glencross, 1970:235; Phillips & Summers, 1954:456).

When attempting to explain practice and experience as related to kinesthesis, Laszlo and Baker make the assumption that kinesthetic feedback teaches reliance on this channel of information. In the study they did on index finger letter writing, they assumed this task to involve relatively novel movements. Thus, the demonstrated reliance on the kinesthetic traces was not available unless there was prior kinesthetic practice on the task (1972:76). In discussing perceptual anticipation, Dorfman and Goldstein state that subjects do not have previous or advance information: instead, they learn through past experience the characteristic pattern of the stimulus events (1975:46). Adams and Dijkstra concur with this assumption (1966:317). Smith postulates that it is possible that man cannot rely on his kinesthetic feedback to provide detailed information about his movements. He gives two reasons for this assumption:

> (1) Man's kinesthetic sense can provide only a gross representation of his movement. He can get a vague "feeling" of the movement, but he cannot perceive the details.
>
> (2) Man is capable of fine kinesthetic perception, but he does not ordinarily attend to the precise feedback, because he is too highly oriented toward external cues (1969:40).

The second assumption appears to be the one being substantiated in the literature. Stallings in her book, Motor Skills, is of the opinion that kinesthetic receptors are sensitive to minute changes (1973:83). Thorsheim et.al., also support this assumption (1974:203).

The sensitivity of kinesthetic perception in limb reproduction has been established in the literature to the degree that it is now assumed that different movement cues have different retention characteristics (Marteniuk, 1973:257; Keele & Ellis, 1972:134). "Thus, in light of the evidence on active movement of the arm, it seems that the type of kinesthetic mechanism involved in discrimination of movement is a qualitative receptor mechanism. In other words, any increase in magnitude of movement activates different populations of receptors in the joint capsule" (Keele & Ellis, 1972:53). Research studies also indicate that limb reproduction involves the processing of two cues, distance information and location information (Marteniuk & Roy, 1972: 477; Laabs, 1973:175; Marteniuk, 1973:257, Keele & Ellis, 1972:134). Distance cues seem to be a less reliable source of codable information than location cues (Laabs, 1973:175; Marteniuk & Roy, 1972:477). Marteniuk and Roy even postulate that distance information is perhaps uncodable when it is the only information available regarding limb displacement 1972:478). In contrast, Laabs study indicated that the effects of information and location information could be controlled but could not be completely separated as general reproduction cues in movement (1974:286-287).

The accurate reproduction of movement in a one handed ball catching task requires precise spatial and temporal orientation and anticipation of the arm and hand. The response can thus be considered the process involved in responding at the best and most precise moment, along with coordinating the sequence of musculature to insure smoothness and accuracy (Dorfman & Goldstein, 1973:45). Spatial and temporal anticipation of the arm and hand are learned processes; spatial anticipation involving learning to predict where a stimulus event will occur, temporal anticipation involving learning to predict when a stimulus event will occur (Dorfman & Goldstein, 1975:46). Therefore, "in order to accurately time responses; i.e., in order to accurately time responses to catch a ball, it is essential to visualize or predict the spatial-temporal characteristics of the ball's trajectory" (Dorfman & Goldstein, 1975:46).

Spatial judgements have been shown to be represented primarily in visual terms, even when based on input from another modality (Attneave & Benson, 1969:221). Even when visual information is distorted, it will still override the input received from the other sensory receptors (Day, 1969: 171; Rock & Harris, 1967:104). Laabs suggests, with support from Keele & Ellis (1972), that spatial-location information required central processing capacity to be retained and decays very little if rehearsal opportunities are not with- drawn (1973:168).

A view widely held among sportsmen is that while spatial anticipation is important for performance, it is the ball's contact with the hand, rather than a temporal prediction of motion, which provides a signal for a grasping movement to be made (Alderson, Sully, & Sully, 1973:218). The cinematographic study done by Alderson, Sully, and Sully dispels the idea that contact between hand and ball constitutes the signal for the grasp to begin (1974:226). The timing of the flexion phase as well as the spatial orientation of the catching hand involved prediction of the ball's motion from flight information sampled relatively early in the trajectory (Alderson, Sully, & Sully, 1974:217). In this study, the orienting movements of the hand began when the ball was still at least six feet away from the hand (1974:224). In a conversion of milliseconds to inches taken from the time scale chart represented on page 222, it was found that the temporally stressed flexion phase of the hand began approximately nine to twelve inches before hand contact (Alderson, Sully, & Sully, 1974:222). Thus, in the learning phases of the ball catching task, it may be necessary for unskilled performers to view the ball until contact so the pattern of the response can be fixed (Kay, 1957:219; Whiting, 1969:34).

According to the research findings presented it appears that practice, experience, and information storage ability are the key factors in acquiring kinesthetic ability and that kinesthetic ability is specific to the task. To what degree any test can adequately measure kinesthesis is questionable in lieu of all the factors that must be controlled (and thus departing from the true skill situation) in order to establish uniformity in an experimental situation. However, it is the design of this study to replicate the true situation as closely as possible and still remain within the boundaries of experimental research.

CHAPTER III

PROCEDURES

Introduction

In studying kinesthesis as a distinct entity the absence of vision is necessary. This study was designed to obstruct the vision of the catching arm while leaving the arm and body full catching mobility. The subject was able to view the ball in it's parabolic flight for thirty feet. The next nine inches were obstructed by an apaque curtain. This chapter examines the process by which the subject's catching ability was measured.

Selection of Subjects

The subjects used in this study were 160 females, excluding those identified as ambidextrious, enrolled in Girl's Physical Education at MacArthur High School in the Aldine Independent School District, Houston, Texas. All female students enrolled in physical education were asked to fill out a sheet (See Appendix C) stating their name, age on last birthday, the hand they write with, their Physical Education class period, and teacher. These sheets were used in selecting the final sample and assigning the subjects to experimental groups. The sheets were handed out one week prior to testing. Students not present on that day were given the sheets as they returned to school. No sheets were collected if not turned in two days prior to testing. All subjects turning in the sheets constituted those subjects eligible for the final sample. Each subject was then assigned a number and then through the use of a random table of numbers they were randomly assigned to one of four experimental groups (See Chapter III, Research Design, page 27).

Testing continued until at least 160 subjects (40 in each experimental group) were tested. Subjects absent on the day(s) of testing scheduled by the researcher were not tested at a later date and were eliminated as subjects.

All subjects were instructed before testing that they would participate in an experiment and that they must be dressed in gym wear to participate. Those students not dressed out did not participate and were eliminated as subjects. All subjects were told the nature of the experiment (See Appendix D).

Description of the Testing Instrument

The testing apparatus consisted of a Jugs Pitching Machine, 20 Dunlop tennis balls, and a blue opaque curtain suspended from the ceiling by an adjustable curtain rod (See Appendix A).

The testing apparatus was set up in MacArthur's dance room where subjects faced a blank wall. This area was chosen because it was isolated and could be shut off from any outside activity.

The blue opaque curtain was "L" shaped. The long side of the curtain was ninety-six inches long and sixty-five inches wide. This side of the curtain was facing the pitching machine. A sixteen inch circular target hole was cut in the material fourteen inches from the inside edge of the curtain and thirty-five inches from the outside edge of the curtain. The circular target hole was thirty-four inches from the bottom of the curtain and forty-six inches from the top of the curtain. It was secured at the top outside edge by a rope connecting the curtain to a pulley suspended from the ceiling beam. This side of the curtain was movable so it could be placed on the left or right side of the curtain rod. The other side of the curtain was thirty-eight inches wide and ninety-six inches long. It was stationary and parallel to the pitching machine. It contained an oval arm sleeve twelve by eight inches in diameter. The sleeve itself was ten inches long. At the end of the sleeve was a piece of elastic inserted in the material to allow for adjustments in arm size. The sleeve was placed and secured just below the arm and shoulder joint of each subject. The sleeve was situated nine inches from the front of the curtain, seventeen inches from the back of the curtain, thirty-four and a half inches from the bottom of the curtain and forty-nine and a half inches from the top of the curtain. The curtain was hung from an adjustable curtain rod secured to the metal beams of the ceiling which allowed it to be adjusted to the shoulder height of the subject. The adjustable curtain rod was thirty-eight inches long. The rod was attached at both ends by two different ropes to two pulleys secured to a metal beam of the ceiling which allowed the curtain to be raised or lowered. The two pulley ropes were secured to two twenty-five pound weights on the floor.

There were four foot positions marked on the floor with colored tape, two for throws to the left hand (red) and two for throws to the right hand (blue). The two position marks for measuring kinesthetic catches to the left or right hand were nine inches from the front edge of the curtain and eight inches apart. The two position marks for measuring visual catches to the left or right hand were fourteen inches from the outside edge of the circular target. They were placed six inches in front of the curtain. Each subject was required to stand in the appropriate area with their hand on the side of their leg before each ball was pitched from the pitching machine.

The pitching machine was thirty feet from the front of the curtain. Positions for the throwing of the ball to the left hand or right hand were marked on the floor in tape. The pitching machine was required to throw the ball on a parabolic flight pattern so that it hit inside the target circle sixteen inches in diameter and thirty feet from the machine. Any ball that did not hit inside the circle or hit the curtain was counted as a mistrial and rethrown.

A pilot study was done one week prior to testing to finalize the test and procedures. At this time the experimental assistants were instructed in their particular duties.

Procedure for the Collection of Data

The back side of the student information sheets were used as data collection sheets (See Appendix C) and were filled out by the researcher after receiving them from the subjects. Information was recorded concerning the subject's number, the experimental treatment group, and whether or not the dominant or non-dominant hand was to be used.

On the day of testing subjects were tested by experimental groups which were randomly assigned an order of testing. Those that participated that day were waiting outside the dance room. The researcher was responsible for getting the subjects ready for the experiment and also responsible for recording the data. The signal to enter the dance room was when the previous subject left the dance room. The subject entered the dance room and was told by the researcher to state her name. The subject was also told that she would be read her instructions. The data sheets on each subject were separated according to experimental treatment groups and the researcher selected the matched pre-planned set of instructions for this experimental group and read them to the subject (See Appendix D). The subject followed the instructions and was able to ask to have them repeated. The experimental assistant was responsible for releasing the balls to each subject as well as collect and return the balls to the pitching machine.

Each subject was tested on one of the four experimental variables: dominant hand-kinesthetic, non-dominant hand kinesthetic, dominant hand-visual, and non-dominant hand-visual. Each subject was given one practice trial before the test and was then scored on the next ten successfully thrown balls. The experimenter asked the subjects if they were ready before each ball was thrown. A total of eleven trials was taken by each subject (one practice; ten scored). If the ball failed to clear the circular target it was not scored and the trial was taken over. If more than twenty trials were taken because of equipment failure, the subject was eliminated.

Research Design

The design used in this study was a 2 by 2 (2x2) factorial design. The factors, vision and kinesthesis, were studied, and each were varied in two ways, dominant hand catching and non-dominant hand catching. There were four possible combinations or cells; dominant hand-kinesthetic, non-dominant hand-kinesthetic, dominant hand-visual, and non-dominant hand-visual. (See Appendix B) These were considered the experimental treatment groups and subjects were randomly assigned to one of them.

CHAPTER IV

RESULTS

The results of this study are presented in three sections: (1) results obtained from the effects of types of catching and hand usage on the number of catches in the ball catching task, (2) results obtained from the effects of vision and kinesthesis and dominant and non-dominant hands on the number of catches in the ball catching task, and (3) results obtained from the effects of types of catching and hand usage on the number of hits in the ball catching task.

Effects of Types of Catching and Hand Usage on the Number of Catches

Table III on page 31 presents a summary of the data obtained on the number of catches in the ball catching task. For a more detailed description of the data, refer to Appendix E, Table VI. A two way analysis of variance was calculated and the results of this are found in the following table.

TABLE II

SUMMARY OF ANALYSIS OF VARIANCE ON CATCHES

Source of Variation	SS	df	MS	F
A Hand Usage	36.100	1	36.100	* 6.675
B Type of Catching	193.600	1	193.600	**35.799
AB Interaction	.625	1	.625	.116
Within Cell	843.650	156	5.408	
Total	1073.975	159		

* $F_{.95}(1,160) \geqq 3.915$

** $F_{.99}(1,160) \geqq 6.805$

Indications from the two way analysis of variance suggest a significant difference $F(1,159)=35.799$ between vision and kinesthesis at the .01 level of significance $F_{.99}(1,160) \geqq 6.805$. An analysis of the data on dominant and non-dominant hand catching ability yielded $F(1,160)=6.675$. An $F_{.95}(1,160) \geqq 3.915$ was needed for significance and this was obtained thus indicating there is a significant difference between catching with the dominant or non-dominant hand. The non-significant interaction $F_{.95}(1,159)=.116$ indicated that the type of catching, visual or kinesthetic, was independent of the hand used, dominant or non-dominant. Therefore, the two variables combine in an additive fashion in that the magnitude of the effects of the type of catching task is constant over the conditions of hand usage. (Winer, 1971:438; Spence, et.al., 1968:181).

Since significant F's were found between vision and kinesthesis and dominant and non-dominant hands, t tests were calculated to ascertain where the significance occurred.

Effects of Dominant and Non-dominant Hands and Vision and Kinesthesis on the Number of Catches

Table III on page 31 gives a summary of the data collected for calculating the t tests. For more detailed information of the data used in obtaining the t test results, refer to Appendix E, Table VI. The following null hypotheses were statistically tested by the t test and the results are as stated:

Hypothesis 1. There is no significant difference between mean DV catching ability scores and mean DK catching ability scores.

The t obtained was t(78)=3.77 which is significant at the .05 level of significance since t(60)=2.000 was required. Therefore, Hypothesis 1 is rejected.

Hypothesis 2. There is no significant difference between mean NDV catching ability scores and mean NDK catching ability scores.

The t obtained was t(78)=4.78 which is significant at the .05 level of significance since t(60)=2.000 was required. Therefore, Hypothesis 2 is rejected.

<u>Hypothesis 3</u>. There is no significant difference between mean DV catching ability scores and mean NDV catching ability scores.

The t obtained was t(78)=1.34 which is not significant at the .05 level of significance since t(60)=2.000 was required. Therefore, Hypothesis 3 is accepted.

<u>Hypothesis 4</u>. There is no significant difference between mean DK catching ability scores and mean NDK catching ability scores.

The t obtained was t(78)=2.67 which is significant at the .05 level of significance since t(60)=2.000 was required. Therefore, Hypothesis 4 is rejected.

TABLE III

SUMMARY OF MEANS AND t TESTS

	Types of Catches						
	Kinesthetic			Visual			
Hand Usage	X	SD	%	X	SD	%	t
Non-Dominant Hand	.975	1.54	9.75	3.30	2.55	33.00	*4.780
Dominant Hand	2.05	1.99	20.50	4.125	2.81	41.25	*3.77
t	*2.67			1.34			

*p .05 t(60)=2.000

Findings indicated significance at .05 level between NDK and NDV $t(60)=4.780$, between DV and DK $t(60)=3.77$, and between NDK and DK $t(60)=2.67$. Significance was not found between NDV and DV $t(60)=1.34$. All four experimental groups caught fewer than fifty percent of all balls thrown to them with the NDK group catching only 9.75%, the DK group catching 20.50%, the NDV group catching 33.00%, and the DV group catching 41.25%.

Since significance did occur in the experimental group's ability to catch the ball, a further and more detailed analysis of these findings was necessary. Thus, a two way analysis of variance was calculated on the number of times the subjects could hit the oncoming ball.

Effects of the Types of Catching and Hand Usage on the Number of Hits

Table IV, page 33, presents a summary of the results of a two way analysis on the number of hits in the ball catching task. For more detailed information on the data used to obtain these findings refer to Appendix E, Table VII. An F ratio was calculated on spatial orientation of the hand on the ball catching task as deduced by the means of the number of times the ball was touched by the hand in the four experimental treatment variables. Refer to Table V for the mean scores. An F for the .05 level of significance $F_{.95}(1,160)\geq 3.915$ was necessary for the F to be significant.

No significant F was found between vision and kinesthesis $F(1,159)=3.518$, dominant and non-dominant hands $F(1,159)=.740$, or between interaction of the two $F(1,159)=1.587$.

TABLE IV

SUMMARY OF ANALYSIS OF VARIANCE ON HITS

Source of Variation	SS	df	MS	F
A Hand Usage	4.557	1	4.577	.740
B Type of Catching	21.757	1	21.757	3.518
AB Interaction	9.505	1	9.505	1.537
Within Cell	964.675	156	6.184	
Total	1000.494	159		

$F_{.95}(1,160) \geqq 3.915$

TABLE V

SUMMARY OF MEANS

	Types of Hits					
	Kinesthetic			Visual		
Hand Usage	X	SD	%	X	SD	%
Non-Dominant Hand	6.35	2.62	63.50	6.10	1.51	61.00
Dominant Hand	6.50	2.26	65.00	5.28	2.48	52.75

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purposes of this study were to attempt to develop a tool to measure kinesthesis in a ball catching task, to assess the subject's ability to catch a ball kinesthetically or visually with their dominant or non-dominant hand, and if, in fact, a difference did occur, evaluate the spatial and temporal orientation of the hand.

Procedures

The initial subjects for this study were 639 female students enrolled in Girl's Physical Education at MacArthur High School the Spring term of 1975. From these possible subjects 160 were randomly chosen, assigned and tested on one of four different experimental treatment variables; catching visually with the dominant hand, catching kinesthetically with the dominant hand, catching kinesthetically with the non-dominant hand, and catching visually with the non-dominant hand.

A two way analysis of variance was used to ascertain whether a statistically significant relationship existed between vision and kinesthesis and dominant and non-dominant hands in the catching task. The two way analysis of variance was calculated on the subject's ability to catch the ball. A two way analysis of variance was also calculated on the subject's ability to touch the ball. When significant F's were obtained on the two way analysis of variance on catches, t tests were used to discover whether statistically significant relationships existed between the four experimental treatment variables.

Results

1. A comparison between vision and kinesthesis in the ball catching task suggests that subjects can catch the ball better visually than they can kinesthetically.

2. A comparison between catching the ball with the dominant hand or the non-dominant hand suggests that subjects can catch better with their dominant hand. However, further analysis of this suggested that this was the case only in the kinesthetic catching task.

3. A comparison between the four experimental treatment variables indicated a significant difference between all group comparisons except the comparison between the two visual groups. The results are as follows:

   a. The dominant hand visual catching ability group performed better than the dominant hand kinesthetic catching ability group.

   b. The dominant hand visual catching ability group performed equally well to that of the non-dominant visual catching ability group.

c. the dominant hand kinesthetic catching ability group performed better than the non-dominant kinesthetic catching ability group.

d. The non-dominant hand visual catching ability group performed better than the non-dominant hand kinesthetic catching ability group.

4. No statistically significant differences were found between vision and kinesthesis and dominant and non-dominant hands in the subject's ability to hit the oncoming ball.

Discussion

There are two aspects involved in the kinesthetic ball catching task. The first being the spatial orientation of the arm and hand in preparing to catch the ball and the second being the temporal orientation of the grasping of the ball by the hands and fingers. The first could be considered to be a gross motor skill and the second, a fine motor skill (Cratty, 1962:213). The combination of the two makes up the ball catching task.

In reviewing the analysis of the subject's ball catching ability it appears that vision is necessary in the ball catching task. However, the analysis of the subject's ability to touch the ball as compared with the rejection of Hypotheses 1 and 2, and the acceptance of Hypothesis 3, suggests that vision is only necessary for the temporal orientation of the grasping of the ball by the hands and fingers. It also suggests that kinesthesis is effective in spatial orientation of the gross motor aspects of the ball catching task.

By accepting Hypothesis 3, it would appear that the subjects could visually catch equally well with their dominant hand or their non-dominant hand. Singer has stated in his book, Myths and Truths in Sport Psychology, that humans are not born with natural ability in sports performance. This is something that is acquired through learning (1975:35). Thus, subjects in this study quite possibly had equal learning experiences in visually catching with their non-dominant hand as they had with their dominant hand. However, in view of the fact that subjects could not kinesthetically catch equally well with their non-dominant hand as they could with their dominant hand indicates that vision is necessary for better performance on the non-dominant hand in the ball catching task. Subjects apparently have more kinesthetic sensitivity in the ball catching task with their dominant hand than they do with their non-dominant hand. This interpretation concurs with the findings reported in research conducted by Phillips and Summers (1954).

In referring to the mean catching scores of the four experimental groups (See Table III, page 31) one finds that the catching task was a difficult one for the subjects in that it was demonstrated that the subjects could not catch fifty per cent of the balls thrown. Thus, the subjects quite possibly did not have much experience in catching tennis balls. However, the subjects did have a higher score in spatial orientation of the arm and hand in the ball catching task. They were able to intercept and deflect the ball during it's parabolic flight pattern in over fifty per cent of the throws (See Table V, page 33). These results suggest that the subjects had previous experience in ball flight patterns in that they were, in a majority of the instances, able to place their hand on an intercept course with the ball. However, these results also suggest that they were unfamiliar with timing the grasping action of the hand in catching the tennis ball since they could make contact with the ball but could not hold on to it. Dorfman and Goldstein present evidence which would support this explanation by stating that spatial and temporal orientation of the hand is a learned process (1975:46).

One observation made by the researcher was that subjects, during the visual ball catching task, watched the ball until it hit their hand which lends support to an assumption that the subjects were of low skill. Or, more precisely, that the subjects had had little practice or experience in the ball catching task. Whiting (1969) and Kay (1957) have made observations which concur with these observations. However, one must also be aware of the fact that vision overrides kinesthesis when the two are presented together (Day, 1966; Rock and Harris, 1967).

In reviewing the analysis of catches and the analysis of hits, evidence is presented which supports the study done by Alderson, Sully, and Sully that it is not the hitting of the ball on the hand that signals the grasping of the ball by the hand and fingers (1974). If the signal for grasping the ball had been the ball touching the hand, subjects would have performed better on the kinesthetic catching tasks than they did (See Table III, page 31). The researcher observed in many cases that the subjects started the grasping action of the hand and fingers before or after the ball had contacted the hand. Thus, they were unable to maintain contact with the ball.

Conclusions

When viewing the findings presented in this study conclusions drawn must be limited to subjects of equal skill ability to those who participated in this research. Based on this limitation, the general conclusions that can be reached from this study are as follows:

1. Subjects do not differ in the spatial orientation of the hand and arm in the visual and kinesthetic ball catching tasks.

2. Subjects perform better in the temporal orientation of the hands and fingers when they are able to view the ball until it hits the hand.

4. In the ball catching task, watching the ball until it hits the hand does seem to be necessary for successful catching. Thus, it does not seem to be the hitting of the ball on the hand that is the signal for the grasping action.

5. The use of a curtain to test kinesthesis in a ball catching task appears to be an adequate tool.

Recommendations

This study could be replicated with various possible design alterations. They are as follows:

1. A comparison study could be made with other tests of kinesthesis for a ball catching task.

2. Highly skilled subjects could be used in the study to acertain whether skill level is related to temporal orientation.

3. Sports implements or other tools could be used to study the subject's ability to catch or hit a ball.

4. The effects of kinesthetic practice could be studied using this tool.

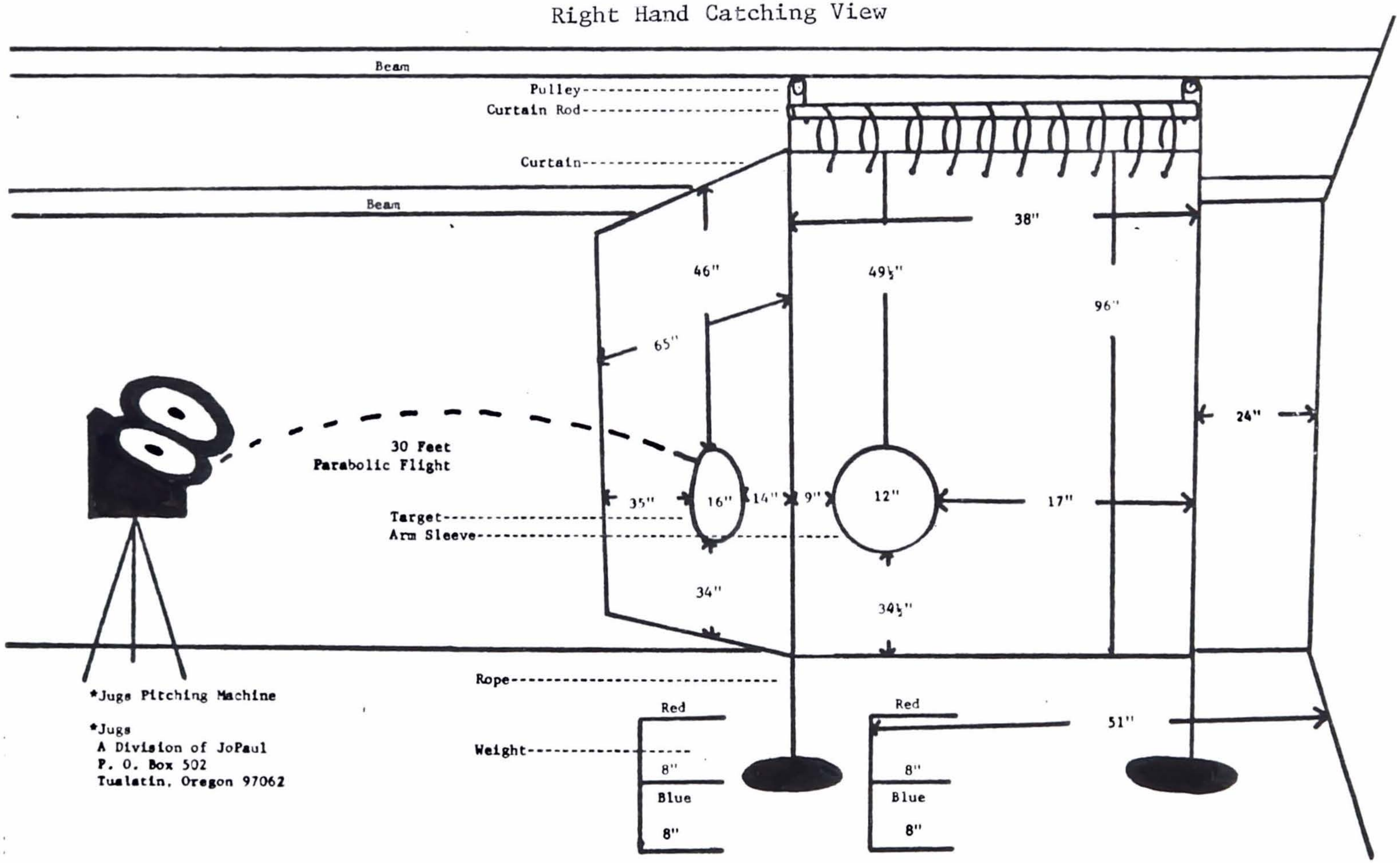
5. A study with emphasis on teaching for kinesthesis or attending to kinesthetic cues could be developed from this study.

APPENDIX A

EXPERIMENTAL LAYOUT

Experimental Layout

Right Hand Catching View



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APPENDIX B

ILLUSTRATION OF A 2 X 2 FACTORIAL DESIGN

Illustration of a 2 x 2 Factorial Design

	Kinesthetic Ability	Visual Ability
Non-dominant Hand Catching	Non-dominant Hand Kinesthetic Ball Catching Ability	Non-dominant Hand Visual Ball Catching Ability
Dominant Hand Catching	Dominant Hand Kinesthetic Ball Catching Ability	Dominant Hand Visual Ball Catching Ability

APPENDIX C

EXAMPLE OF THE DATA SHEET

Data Sheet

FRONT

Name ________________________________
 Last First

Teacher (circle one) Hays Bourgeois
 Kleinpeter Watz

PLEASE FILL OUT ALL INFORMATION ON THIS SIDE OF THE SHEET ONLY

Your age (circle one) 12 13 14 15
 16 17 18 19

Hand you write with (circle one) Left Right

P. E. class period (circle one) 1 2 3 4 5 6 7

BACK

S# ______________ Ex. Group ______________ D or N-D __________

1. ______	6. ______	11. ______	16. ______	Total Caught ___
2. ______	7. ______	12. ______	17. ______	Total Missed ___
3. ______	8. ______	13. ______	18. ______	Total Hit ______
4. ______	9. ______	14. ______	19. ______	
5. ______	10. ______	15. ______	20. ______	

APPENDIX D

VERBAL INSTRUCTIONS

Description of Experiment to Subjects

During the next week you will participate in a study where you will do one of four things; you will either attempt to catch a ball with your right hand, or attempt to catch a ball with your left hand, or attempt to catch a ball with your left hand when you can't see your hand, or attempt to catch a ball with your right hand when you can't see your hand. Tennis balls will be thrown to you by a machine which will allow you to see the ball being thrown. This will be done in the dance room and when you walk in you will be told what you are to do.

Experimental Groups Explanations

Group I

Please go to the area on the floor marked in red and place your feet on the two red areas. You will put your left arm in the sleeve hanging from the blue curtain and then place your hand to your side.

Eleven balls will be thrown to you from the ball machine and you are to attempt to catch as many of them with your left hand as you can. The first ball thrown will be a practice but the next balls thrown will be scored on how many you can catch and hold for one second. After you have caught and held the ball for one second, let it drop to the ground. After each try, whether you catch the ball or not, return to the red area and place your hand by your side. You may take a step in an attempt to catch the ball. Would you like to have these instructions repeated? (pause for test) Thank you for your help in making this experiment possible.

Group II

Please go to the area on the floor marked in red and place your feet on the two red areas. Now, place your left hand on your left side.

Eleven balls will be thrown to you from the ball machine and you are to attempt to catch as many of them with your left hand as you can. The first ball thrown will be a practice but the next ten balls thrown will be scored on how many you can catch and hold for one second. After you have caught and held the ball for one second, let it drop to the ground. After each try, whether you catch the ball or not, return to the red area and place your hand by your side. You may take a step in an attempt to catch the ball. Would you like to have these instructions repeated? (pause for test) Thank you for your help in making this experiment possible.

Group III

Please go to the area on the floor marked in blue and place your feet on the two blue areas. You will put your right arm in the sleeve hanging from the blue curtain and then place your hand to your side.

Eleven balls will be thrown to you from the ball machine and you are to attempt to catch as many of them with your right hand as you can. The first ball thrown will be a practice but the next ten balls thrown will be scored on how many you can catch and hold for one second. After you have caught and held the ball for one second, let it drop to the ground. After each try, whether you catch the ball or not, return to the blue area and place your hand by your side. You may take a step in an attempt to catch the ball. Would you like to have these instructions repeated? (pause for test) Thank you for your help in making this experiment possible.

Group IV

Please go to the area on the floor marked in blue and place your feet on the two blue areas. Now, place your right hand on your right side.

Eleven balls will be thrown to you from the ball machine and you are to attempt to catch as many of them with your right hand as you can. The first ball thrown will be a practice but the next ten thrown will be scored on how many you can catch and hold for one second. After you have caught and held the ball for one second, let it drop to the ground. After each try, whether you catch the ball or not, return to the blue area and place your hand by your side. You may take a step in an attempt to catch the ball. Would you like to have these instructions repeated? (pause for test) Thank you for your help in making this experiment possible.

APPENDIX E

RAW DATA FROM THE EXPERIMENTAL GROUPS

TABLE VI

RAW DATA FROM THE EXPERIMENTAL GROUPS
NUMBER OF COMPLETED CATCHES

Ss	NDK	NDV	DK	DV
1	0	2	0	0
2	0	5	0	4
3	0	0	3	3
4	2	4	4	3
5	0	0	5	5
6	0	5	2	7
7	0	7	3	1
8	0	2	0	4
9	0	2	4	9
10	0	5	3	6
11	1	4	0	9
12	5	1	1	1
13	0	2	0	1
14	2	0	3	6
15	1	0	0	3
16	5	2	0	10
17	0	4	1	2
18	1	2	0	8
19	0	1	5	6
20	0	4	6	6
21	1	2	1	5
22	0	4	0	0
23	2	1	4	5
24	0	4	1	3
25	0	7	0	6
26	0	2	4	6
27	0	9	0	1
28	1	6	5	0
29	2	0	5	1
30	3	0	7	1
31	1	0	1	4
32	0	4	4	6
33	5	8	1	9
34	5	0	1	5
35	0	5	2	0
36	0	5	0	4
37	1	8	2	1
38	0	7	1	7
39	0	3	1	5
40	1	5	2	2
Total	39	132	82	165

TABLE VII

RAW DATA FROM THE EXPERIMENTAL GROUPS
NUMBER OF HITS

Ss	NDK	NDV	DK	DV
1	4	6	9	9
2	9	5	9	6
3	10	10	5	7
4	6	6	6	6
5	10	8	5	5
6	10	5	7	3
7	2	3	7	6
8	8	7	6	6
9	0	7	5	1
10	4	5	7	4
11	9	5	9	1
12	5	7	9	9
13	5	8	8	9
14	8	9	6	3
15	6	9	10	7
16	3	7	2	0
17	1	6	9	7
18	5	4	7	2
19	10	5	5	4
20	5	8	4	4
21	8	6	8	5
22	8	7	9	8
23	4	6	6	4
24	3	3	9	7
25	9	7	9	4
26	6	1	5	4
27	6	4	5	9
28	9	10	5	10
29	7	9	4	6
30	7	10	8	6
31	9	6	3	5
32	10	2	7	4
33	4	7	5	1
34	5	5	8	5
35	3	5	6	7
36	6	2	8	5
37	8	3	0	8
38	8	7	8	2
39	8	5	6	4
40	6	9	6	8
Total	254	244	260	211

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