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The effectiveness of the ski simulator in measuring the foot-eye coordination of college skiers and college nonskiers

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THE EFFECTIVENESS OF THE SKI SIMULATOR IN MEASURING

THE FOOT-EYE COORDINATION OF COLLEGE

SKIERS AND COLLEGE NON-SKIERS

———————

A Research Project

Presented to

The Graduate Faculty

Ithaca College

———————

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

———————

by

Stephen Lee Klingman

September 1975

School of Health, Physical Education and Recreation

Ithaca College
Ithaca, New York

CERTIFICATE OF APPROVAL

M.S. RESEARCH PROJECT

This is to certify that the Research Project of

Stephen Lee Klingman

submitted in partial fulfillment of the requirements for the degree of Master
of Science in the School of Health, Physical Education and Recreation at Ithaca
College has been approved.

Director of Graduate Studies:

Chairman of Graduate Studies,
School of HPER:

Research Project Advisor:

Candidate:

Date:

ACKNOWLEDGMENTS

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Chapter 1

INTRODUCTION

In order to attain a high level of achievement
in most sports, an individual must possess a high degree
of coordination necessary for that sport. It was previ-
ously believed that coordination was a general motor
ability. Studies completed in the area of motor learning
and motor performance by researchers such as Henry (19),
Singer (62), Oxendine (53), Bachman (22), and Lempce (16)
have indicated that coordination tends to be task specific
rather than a general motor ability. That is, an athlete
may be highly coordinated in one particular type of move-
ment while being uncoordinated in another movement. For
example, a downhill skier must possess good foot-eye
coordination to be able to ski smoothly and efficiently
down the slopes. He must also possess accurate visual
perception so that he may recognize details 40 to 50 feet
away in order to manipulate his body and skies to prevent
an injury. On the other hand, a baseball infielder may
possess a lesser degree of foot-eye coordination than the
skier, but it is essential that he possess exceptional
hand-eye coordination. The baseball player, in contrast
to the skier, must be able to field batted balls flaw-

lessly and maintain a moderately high batting average.

In the United States greater attention is focused upon the acquisition of hand-eye coordination than in the learning of foot-eye coordination tasks. The majority of sports that are played in the United States require the performer to possess skilled hand-eye coordination to reach his full potential in a particular sport. In most other countries of the world, due to the fact that soccer is the most popular sport, there is a greater emphasis on the acquisition of foot-eye coordination.

There are still many unanswered questions regarding neuromuscular coordination and the acquisition of hand-eye and foot-eye coordination. Reliable and valid tests have not been developed to specifically measure foot-eye coordination. In this investigation, an attempt was made to measure foot-eye coordination of college skiers and college non-skiers using the ski simulator.

Statement of the Problem

The purpose of the study was to determine the effectiveness of the ski simulator in measuring the foot-eye coordination of college skiers and college non-skiers.

Significance of the Study

Morehouse (9) stated that eye muscle coordination plays a dominant role in the acquisition of a motor skill. As a performer improves in the skill, the eye muscle factor becomes less dominant. When the individual perfects the

skill, such as the technique required for downhill skiing, he can perform the skill blindfolded. This does not mean that the skier could ski down the slope blindfolded, but the skier could perform the different skills required in skiing without the use of his vision. Thus the proficient skier can use his vision to be acutely aware of obstacles in the surrounding environment in order to prevent injuries to himself as well as other skiers.

As previously mentioned, a skier must recognize obstacles 50 or more feet in front of him while skiing at speeds exceeding 30 miles per hour in order to avoid injuries. A skier who has little experience cannot possibly concentrate on technique and also avoid dangerous obstacles in the surrounding environment. The injury rate, as reported in the Encyclopedia of Sport Science and Medicine (5:566), supports the above statement. The expert's injury rate is 2.9/1000 ski-man days; the intermediate rate is 4.9/1000 ski-man days; while the beginner's injury rate is 16.0/1000 ski-man days. The beginning skiers account for only 21 percent of those on the slopes, but are involved in 55 percent of the injuries. The beginning skier may also cause injury to another skier through failure to have learned the simplest of control maneuvers.

A person who possesses a high degree of foot-eye coordination has an advantage over an individual who has a low amount of foot-eye coordination in the acquisition and performance of skills requiring this factor. A beginner

skier must develop foot-eye coordination and skiing technique. His skill level is inferior to that of the more experienced skier. The novice skier, or individual with little experience or skill in the sport, should ski on the beginning slopes. He should allow a period of time to master the basic skills of the sport before progressing to the more difficult slopes.

If it is found that the ski simulator is effective in distinguishing a difference in performance between the Skiers and Non-skiers, it's use may aid in the reduction of ski injuries sustained by skiers. Beginning skiers who score poorly on this test of foot-eye coordination may be discouraged, or even prohibited, to ski on the more difficult slopes before a designated period of time is spent on the beginner slope. It may also be recommended that these skiers receive some instruction from a certified ski instructor. Hendryson states (5:1590):

> At any time on the hill approximately 25 percent of the skiers have had 10 or more formal lessons in definite ski-school instruction. These skiers rarely get hurt. But those who have had five lessons or fewer have an accident rate of almost 35 percent.

There are also other practical values in the measurement of foot-eye coordination. Skiers who are involved in an introductory or beginning ski course possessing a high degree of foot-eye coordination could be placed in an advanced beginner class. These persons may be able to learn the basic fundamentals of skiing in a shorter time period and also save the funds which are necessary for many

ski lessons. Money saved may be utilized for the purchase
of better ski equipment. Better equipment may help to keep
the injury rate to a minimum. Children and adults who pos-
sess good foot-eye coordination may be invited to partici-
pate in the sport of skiing, or other sports in which foot-
eye coordination is an important quality. Smith (17)
stated that a reliable test of foot-eye coordination could
be used as part of the selection of personnel for eye-foot
activities such as kicking a football or participating in
the sport of soccer.

Scope of the Problem

The data were collected for the study in the Spring
of 1973. The subjects (N=60) who participated in the
investigation were 49 students who were enrolled at Ithaca
College during the Spring semester of 1973, and 11 students
who planned to enter college in the Fall of 1973. The sub-
jects comprised 2 equal groups and ranged in age from 17
to 25 years. The mean age of the 60 subjects was 20.69
years. Thirty students were selected who had no previous
skiing experience prior to their testing on the ski simu-
lator. This group was referred to as the College Non-
skiing group. Thirty subjects were also selected who had
skied a minimum of three years. This group was referred
to as the College Skiing group.

Subproblems

The subproblems of the study were as follows:

1. What was the difference in foot-eye perfromance between the two groups when the ski simulator was operating at slow speed?

2. What was the difference in foot-eye performance between the two groups when the ski simulator was operating at medium speed?

3. What was the difference in foot-eye performance between the two groups when the ski simulator was operating at fast speed?

Major Null Hypothesis

There will be no significant difference in foot-eye coordination of college skiers and college non-skiers as measured by the ski simulator.

Minor Null Hypotheses

Three minor null hypotheses were stated for the investigation as follows:

1. There will be no significant difference in foot-eye coordination between college skiers and college non-skiers when the ski simulator is operating at slow speed.

2. There will be no significant difference in foot-eye coordination between college skiers and college non-skiers when the ski simulator is operating at medium speed.

3. There will be no significant difference in foot-eye coordination between college skiers and college non-skiers when the ski simulator is operating at fast speed.

Definition of Terms

The following terms were operationally defined for
this study:

General Motor Coordination. General motor coordination
is the ability of the individuals to use the correct
muscles at the proper time, utilizing the proper force
required to perform a desired movement (7).

Eye-foot Coordination. Eye-foot coordination is the use
of perception in aiding in the smooth, efficient sequence
of movement that results from a precise and controlled
action of several muscle groups (6).

College Skiers. College skiers are college students who
have skied for a period of not less than three years prior
to being tested on the ski simulator.

College Non-skiers. College non-skiers are college students
who have not previously skied prior to being tested on the
ski simulator.

Ski Simulator. The ski simulator is an instrument utilized
for the measurement of foot-eye coordination.

Assumptions

The following assumptions were made for this study:
1. All subjects performed to the best of their ability
while being tested on the ski simulator.

Limitations

The study had the following limitations:
1. A random sample was not used in this study.

2. The ski simulator had minor mechanical limitations. The setting of the dial on the ski simulator at one speed in testing a subject closely approximated, but may not have been identical to, the previous setting at the same speed in testing a different subject.

Delimitations

The study had the following delimitations:

1. The college skiers had at least three years skiing experience. Each subject must have skied regularly during each year. It was realized that some skiers had more experience than others due to such factors as: time available for skiing, money, weather conditions, and more interest in the sport.

2. The college non-skiers had no experience in the sport of skiing prior to their testing on the ski simulator.

Chapter 2

REVIEW OF RELATED LITERATURE

The majority of research in the area of neuro-
muscular coordination is concerned with hand-eye coordi-
nation. There has only been a very limited number of
investigations completed in the area of foot-eye coordi-
nation and in the measurement of this specific ability.
Smith (17) completed an extensive review of the literature
concerning foot-eye coordination and the testing of this
specific ability. However, he reported having failed to
find any foot-eye coordination studies prior to 1966.

Since 1966, a small number of investigations have
been completed in the specific area of foot-eye coordi-
nation (17,31,65,66). Most of the researchers have utilized
adaptations of hand-eye coordination testing apparatus to
measure foot-eye coordination. The reliabilities of these
testing devices have been low. As a result, there is a need
for the development of instrumentation so that more sophis-
ticated studies may be undertaken.

This chapter will be subdivided into two major
sections. The first section will be concerned with the
specificity and generality theories in the learning and the
performance of motor tasks. The final portion of the

chapter will be concerned with studies completed in the area of foot-eye coordination and tracking skills.

Generality/Specificity of Motor Skills

The theory of generality and specificity of motor performance is very important to the measurement of foot-eye coordination of college skiers and college non-skiers. As will be indicated, the majority of recent research (16, 22,28,31,32,40,53,62) reveals that motor performance and the learning of motor skills are task specific. The type of foot-eye coordination necessary in the sport of downhill skiing may not be that which is needed to dribble a soccer ball or field a baseball. Henry's (19) findings in the area of transfer of coordination from one skill to another show that transfer only occurs if the second skill is very similar, or almost identical, to the original skill. In 1903, Thorndike formulated his 'Identical Elements Theory' concerning the transfer between similar skills which is summarized by Sage:

> His identical elements theory proposed that transfer of learning occurs to the extent that identical components exist in the two specific tasks, and therefore if general training is effective in producing improvements in learning efficiency in a variety of tasks, it is because the components, or elements, of specific tasks are practiced in the process of general learning (12:355).

In this investigation the ski simulator was used to measure the foot-eye coordination of college skiers and college non-skiers. In order to distinguish college skiers from college non-skiers, the foot-eye coordination needed

to perform well on the ski simulator must be very similar to that which is necessary in the actual sport of skiing. Only after testing the foot-eye coordination of athletes in other sports, using the ski simulator, will the investigator be able to determine if foot-eye coordination of skiers is similar to the foot-eye coordination of soccer, baseball, or hockey players.

Early Generality/Specificty Theory

In the early 1900's Spearman (13) investigated a 'G' or general factor that was believed to underlie all intellectual tasks. The introduction of the Spearman 'G' and the formulation of many intelligence tests to locate this factor, led prominant motor learning researchers to investigate the possibility of a general factor which was basic to all motor performance. Brace (2) was one of the first motor learning researchers to try to locate a general factor underlying all motor performance. He designed a number of skill tests to find a general factor. McCloy (51), another early motor learning researcher, was interested in constructing a test of general motor capacity which would be analogous to the test of general intellectual capacity. This test would measure the capacity an individual could reach in the performance of a motor task. In defining the term 'general' in relation to general motor capacity or general motor ability, McCloy (51:46) implied that "these motor capacities measured are the basic fundamental ones that apply to almost all motor performance."

Investigations by prominent researchers such as McCloy (51), Brace (2), and Larson (46) stimulated other researchers to conduct similar investigations. Perrin (54) completed one of the first investigations in which the conclusions supported the specificity of motor performance. In 1921, 51 undergraduate students at the University of Texas served as subjects, and were each tested on 17 different motor tasks. Three of these tasks were classified as complex motor skill, i.e., the Bogardus fatigue test, a card sorting task, and a two-handed dexterity skill. Additionally, Perrin utilized 14 tests to measure elementary motor functions, e.g., reaction time, balancing of various kinds, rhythmic counting, and strength. The results of Perrin's investigations produced low correlations between performance tests. Therefore, Perrin concluded that motor ability was not general, but that it was specific to each task. He summarized his views pertaining to the specificity of motor abilities in the following quotation:

> We can believe, of course, without question
> that physical strength is, generally speaking,
> physical strength; and that a capable piano mover
> might qualify at the task of loading railroad ties.
> But it does not follow that the speed required in
> baseball is the speed needed in typewriting, or
> that the rhythm necessary in dancing is that
> involved in the coordination test (54:51).

Approximately two years after Perrin (54) completed his study, Garfiel (34) investigated the measurement of motor ability. Garfiel tested subjects on a battery of tests measuring speed, motor control, coordination, and strength. The test included two-handed trick type coordi-

nations such as rubbing the stomach and patting the head simultaneously, balancing skills, a ball toss for accuracy, tapping for speed, and some measurement of rhythm. The intercorrelation of tasks ranged from .15 to .25 which indicated the high degree of specificity of these motor skills. In the second portion of the same study, Garfiel had physical education teachers rate each subject on athletic ability. There was a .77 correlation between the teachers' ratings and the results of the motor ability tests. The 10 best students according to the teachers' ratings were also the 10 highest on the test battery. Garfiel interpreted this finding as due to the possible existence of a general motor ability.

Cozens (18), one of the first researchers to find positive significant correlations between gross motor abilities, completed an extensive study concerning these abilities in 1929. Following his investigation, Cozens concluded that there was some generality in gross motor ability which contradicted the findings of Perrin (54) and Garfiel (34). However, after reviewing Cozen's study, Seashore (61) noted that the majority of correlations were between .20 and .30. Seashore therefore concluded that Cozen's data supported the specificity of gross motor skills rather than the generality of motor skill hypothesis.

In 1934, Hoskins (45) completed a study of the relationship of a battery of tests measuring general motor ability and general motor capacity to the specific motor

skills learned in physical education. The subjects who participated in the study were freshmen attending the University of Virginia in the Fall of 1932. The tests given to each subject were the General Motor Ability test and the General Motor Capacity test. Each subject participated in either basketball, boxing, handball, tap dancing, or individual activities. Swimming was a required course. The majority of correlations were below .50 and non-significant which, according to Hoskins, supported specificity rather than generality of motor performance.

One year after Hoskins (45) completed his study, Jones (20) reached similar conclusions after an extensive investigation in which 2000 males participated. Jones studied the relationship of gross motor skills and analyzed the performance scores of subjects in order to locate what he designated as fundamental motor skills. Four motor tasks were used in the investigation: running high jump, a sprint run, rope climb, and a baseball throw for accuracy. All the resulting correlations were low and these non-significant correlations indicated the absence of an important relationship between the four motor tasks. Jones concluded from the results of his investigation that the data supported the specificity of motor performance.

Freeman (33) and Seashore (61), two early motor learning researchers, completed investigations in 1942. Freeman (33) investigated the relationship between several fine motor tasks which he called a needle and thread task,

top winding, a maze test, and mirror drawing. Seashore (61) investigated the relationship between fine and gross motor abilities, administering a battery of balance and steadiness tests on two groups of college men. The difference in scores between the two groups, known to differ in athletic ability, was non-significant. Both researchers' data, which showed low correlations between the tasks utilized, led them to similar conclusions. Motor performances, they contended, depend largely upon specific abilities related to their specific motor areas.

The majority of early investigations in the area of motor ability concerned the generality or specificity of motor performance rather than motor learning. In 1942 Gire and Espenschade (35) investigated the relationship between measures of motor educability and the learning of specific motor skills. The subjects who participated in the investigation were 195 senior high school students. Their achievement and performance scores on basketball, baseball, volleyball skill tests; and the Brace test, Iowa-Brace test, and Johnson Motor Educability test were recorded. Correlations obtained between the motor educability tests and various achievement scores were -.29 to .29 for basketball, -.05 to .12 for volleyball, and -.19 to .17 for baseball. According to the results, the researchers concluded that there was a high degree of specificity of motor performance and motor learning.

With the introduction of factor analysis, more

sophisticated investigations were undertaken to find the factors underlying motor ability. Cumbee (29), and Cumbee, Meyer, and Peterson (30) completed studies to determine which factors were present in variables that had been used in the past as measures of coordination. In the initial study, Cumbee (29) analyzed 21 selected motor skills using the multiple group method of factoring. Eight factors from the intercorrelations of the 21 variables were extracted and 5 were given names: balancing objects, tempo, two-handed dexterity, speed and change of direction of the arms and hands, and body balance. Cumbee concluded that variables that were used in the past to measure motor coordination, proficiency, and sport skills group themselves around certain abilities. This conclusion indicated that some generality of coordinations existed, but also that further factors not considered in this investigation were pertinent to motor coordination.

As a follow-up to Cumbee's initial study, Cumbee, Meyer, and Peterson (30) completed a similar investigation to determine which factors were present in motor coordination tests. Third and Fourth grade girls served as subjects in this study. The multiple group method of factoring was again utilized and produced nine clusters. Four of the nine clusters were given names: balancing objects, body balance, speed of change of direction of the arms and hands, and total body quick change of direction. It was concluded by the researchers that a different definition of motor

coordination should be considered for different age groups. These data supported the task specificity of motor coordination.

In the early 1900's prominent motor learning researchers such as McCloy (51), Brace (2), and Larson (46) suggested that there was a 'general motor ability' underlying all motor performance. As early as 1920, researchers such as Perrin (54) and Garfiel (34) concluded that motor ability was more specific than was previously believed. Other early motor learning researchers such as Jones (20), Hoskins (45), Seashore (61), Gire and Espenschade (35), Freeman (33), Cumbee (29), and Cumbee, Meyer, and Peterson (30) supported the specificity theory of motor performance.

Recent Studies in Specificity/Generality Theory

Since 1955 several investigations were completed which supported the specificity of motor performance and also the specificity of motor learning. One of the most prominent motor learning researchers, Henry, completed many investigations concerning the specificity of motor skill acquisition (37,38,39,40,41,42). Henry and Nelson (40) completed a study in 1956 investigating the interrelationships between performance and the learning of motor tasks by 10 and 15 year old boys. The majority of studies prior to Henry and Nelson's investigation were primarily concerned with the specificity of motor performance rather than with the specificity of motor learning. Participating in the

study were 72, 15 year old; and 73, 10 year old boys. Three
motor tasks involving important basic elements of game
skills were performed by the subjects. These tasks were
similar in nature and involved stimulus discrimination.
Henry and Nelson concluded that task specificity was great,
even in the learning of similar gross motor tasks. However,
specificity was shown to be less in the younger groups of
subjects.

One of Fleishman's (31) many investigations for
testing pilots in the United States Air Force was completed
in 1958. Fleishman was interested in finding the relation-
ship between individual differences in positioning move-
ments and static reaction tasks required in piloting air-
craft. The positioning task involved moving the various
limbs to a specific point in space in which terminal
accuracy of the response was measured. The limb must be
held steady while in a fixed position for the static reac-
tion task, and the maintenance of this position is the cen-
tral task. All of the more than 200 intercorrelations were
low, with 90 percent ranging between -.20 and .20. These
results led Fleishman to conclude that ability in these
kinds of coordination is highly specific to the task.

In 1961, Bachman (22) completed an investigation
to determine the degree of specificity or generality that
was involved in the learning and performance of two large
muscle motor tasks. The total number of subjects who
participated in the study were 320, 160 male and 160 female.

These subjects were equally divided into 20 single year
groups ranging in age from 6 to 26. Each group consisted
of eight male and eight female participants. A significant
amount of learning resulted on both tests; 44 percent on
the free standing ladder climb, and 59 percent on the
stabilometer. There was no significant correlations for any
of the age groups, which showed a high degree of specificity
present in the learning of these tasks. The highest non-
significant correlations were found between subjects ranging
in age from 6 to 11 years, which indicates some generality
of learning at early ages. These results tend to agree with
the results of Henry and Nelson (40) that some degree of
generality may exist in the younger age groups. Not only
was the task specificity of learning great, but the speci-
ficity of motor performance was also large. Only 1 out of
12 correlations was found to be statistically significant.
Furthermore, these correlations were low and indicated a
negative relationship between skills in the two tasks.

In the same year as Bachman's study, Cratty (28)
completed a study to determine whether a common factor
of motor educability was present in the learning of two
maze tasks. The mazes had similar patterns but occupied
different amounts of space. Sixty college students were
divided into 2 equal groups of 30, and each subject was
given 12 speed trials to learn the maze pathways. After
the 12th trial, the groups exchanged tasks. Product moment
correlations were computed for (1) the difference between

traversal speed on the first and last trial, (2) the difference between the third and last trial, and (3) the difference between the slowest and fastest trial. The correlations between the 1st and last trial were .24; between the 3rd and last trial, .00; and between the slowest and fastest trial, .23. None of the three correlations were statistically significant which indicated the specificity of learning motor tasks.

Fleishman and Ellison (32) completed a factor analysis of fine manipulative tests to determine the degree of specificity or generality in the performance of these tasks. In 1962, the researchers tested 760 subjects on 22 manual dexterity tasks. Five factors were isolated and given names: wrist-finger speed, speed of arm movement, finger dexterity, manual dexterity, and aiming. The results of the study led the researchers to the conclusion that there was a high degree of specificity of performance of these fine manipulative tasks.

Oxendine (53) completed an investigation to determine the degree of generality or specificity present in the learning of fine and gross motor skills. Forty high school boys and girls served as subjects. The test included mirror tracing and a pencil maze, the fine motor skills; and a disc tossing and hop scotch type skill, the gross motor tasks. The subjects practice each skill on five consecutive days in trials of three. The learning scores were calculated by finding the difference between the first and best trial of

each day. The amount of generality in learning these various tasks was computed, and the correlations indicated that the subjects did not improve similarly on the various tasks. Significant correlations were found between the disc tossing and the hop scotch type skill, the two gross motor tasks. A significant correlation was also found between the disc tossing skill and the mirror tracing, both perceptual motor tasks. The degree of generality was slight and too low to be of predictive value. General intelligence and scholastic achievement were found not to be related to learning or performance ability in the skills tested.

The major study which yielded contradictory findings to those supporting specificity theory was the investigation completed by Robichaux in 1960. Robichaux (59) computed intercorrelations between five newly learned skills and skill tests. Intercorrelations between the skill test scores and the newly learned skills ranged from .16 to .79 with all, except 1, being significant at the .01 level. Robichaux concluded that a performer's past motor performance appeared to be indicative of his performance level in new gross motor skills, which supported the generality of performance theory.

Singer (62) investigated the interlimb skill ability in motor skill performance in 1966. Thirty-eight college freshmen were tested on 2 skills; throwing a softball for accuracy, and kicking a soccer ball for accuracy. Trials were 30 seconds in duration and both the preferred and non-

preferred arms and legs were used. Five of the six cor-
relations were low but positively significant: preferred
arm and non-preferred arm, preferred leg and non-preferred
leg, preferred arm and non-preferred leg, preferred arm and
preferred leg, and non-preferred arm and non-preferred leg.
When analyzed for generality and specificity factors, the
highest percentage of variance common to both variables,
referred to as the generality correlation, was 29 percent
comparing the preferred leg and non-preferred leg. Singer
concluded that there existed a strong specificity in limb
performance.

One of the most recent investigations concerning
the specificity of motor learning was completed by Lempce
(16) in 1970. Lempce was interested in determining the
degree of generality or specificity in the ability to learn
and perform four gross perceptual motor tasks; amd also to
determine the relationship of selected physical and mental
components to the learning and performance of these motor
tasks. Forty-six male children between the ages of 10 and
12 participated in the investigation. The four gross per-
ceptual tasks included a tennis wall volley, a soccer wall
volley, volleyball wall volley, and a soccer punt for
accuracy. Each subject was given three practice trials for
a period of six consecutive days. All the trials were 20
seconds in duration with the exception of the soccer punt,
in which the subject was given 5 trials. Each subject was
also tested on 14 other physical and mental components,

e.g., intelligence, academic achievement, depth perception, agility. The scores obtained from these tests were correlated with the scores of the four motor tasks. Learning score correlation coefficients did not vary significantly from zero or were too low to be of predictive value. Lempce concluded that a high degree of specificity existed in the learning of the tennis, soccer, volleyball, and soccer punt tests. There was a high degree of specificity present in the initial performance of the four tasks, but after the initial trial a moderate degree of generality was exhibited in the performance of the four tasks. Lempce also concluded that the mental components of intelligence, academic achievement, and relative academic achievement were not related to the learning and performance of the four motor tasks. This finding is similar to that of Oxendine (53).

Specificity of Movement Speed and Reaction Time

The majority of studies in the previous section of this chapter supported the specificity of performance and learning of motor skills (16,18,20,22,28,29,30,31,32, 33,34,35,40,45,53,54,61,62). Researchers were also interested in determining whether specific aspects of motor ability were specific to the situation or were general factors. The studies that are discussed in this section were completed to determine if speed of movement and reaction time are specific factors and independent of one another.

Henry (37) completed an investigation in 1952 to determine if reaction time and movement speed were inde-

pendent abilities. Sixty subjects were given 5 trials each on a ball snatch and 20 trials each on a treadle press. Each subject's responses were fractioned into movement speed and reaction time components through the use of two chronoscopes. Reliabilities of the tasks ranged from .79 to .84 for reaction time, and .73 to .79 for movement speed. Correlations ranged from -.07 to .15 and were not found to be statistically significant. Henry concluded that movement speed and reaction time were uncorrelated and independent.

Slater-Hammel (63) completed a study similar to Henry's in the same year. Twenty-five physical education majors served as subjects at Indiana University, and were each tested on a horizontal movement of the right arm through a 120 degree arc. Correlational analysis of the relationships between several measures of movement duration and reaction time resulted in correlation coefficients ranging between .07 and .17. These non-significant correlations led Slater-Hammel to conclusions similar to Henry's (37), supporting the independence of movement speed and reaction time.

Hipple (43) investigated the racial differences in motivation on muscular tension, reaction time, and speed of movement. Sixty male subjects between the ages of 12 and 44 years participated in the study and were divided into equal groups of 30 subjects according to race. Hipple measured the speed of motor response and found low correlations between reaction time and movement speed, .23 for Negroes

and .38 for Caucasians. Hipple found that the highest cor-
relations existed in the Caucasian group between the ages
of 12 and 14 years. These results are similar to those of
Henry and Nelson (40) and Bachman (22). They also indicated
that some generality of learning may also be present at
young age levels.

Henry and Rogers (41) stated that reaction time
and movement speed would lengthen as a task became more
complex, and formulated the 'memory drum theory' to explain
this phenomena. The researchers are of the opinion that
over a period of several years there is stored an abundance
of unconscious motor memory available for acts of neuromotor
skill. When a complex skill is performed, a more compre-
hensive program is needed and the neural impulses will need
a longer period of time for coordination and direction into
motor neurons and muscles. To determine if their theory
was tenable, Henry and Rogers completed an investigation
in which 120 subjects of different age levels participated:
4th grade boys (N=20), 8th grade boys (N=20), college males
(N=30), college females (N=30), and males ranging in age
from 19 to 35 years (N=20). The test consisted of three
movements ranging in complexity from a simple releasing of
a reaction key; to a more complex combination of releasing
a reaction key, striking a hanging tennis ball, pushing a
button to the left of the reaction key, and finally
grasping a second hanging tennis ball. The results showed
that all groups reacted more slowly as the movement became

more complex. Henry and Rogers also concluded:

> Individual differences in speed of arm move-
> ment ability are predominantly specific to the
> type of movement that is made (70%); there is
> only a relatively small amount of general ability
> to move the arm rapidly (41:457).

In 1960, the same year as Henry and Rogers (41)
completed their study, Henry and Whitley (42) investigated
the relationship between individual differences in strength,
speed, and mass in arm movement. College males participated
in the study and formed 2 groups, $N_1 = 30$ and $N_2 = 35$. Henry
and Whitley found no significant correlation between static
strength and strength in action. The absence of a signif-
icant correlation indicated the high specificity of neuro-
motor coordination skills. Reaction time and movement speed
showed no significant correlation.

Clarke (24) completed an investigation similar to
the study of Henry and Whitley (42) in 1960. Clarke meas-
ured the strength/mass ratio and speed of lateral arm move-
ment of 48 college students. The movement speed trial con-
sisted of each subject moving his right arm in a horizontal
plane a distance of 117 centimeters when an auditory signal
was given by the researcher. For the strength test, the
subject was in a supine position with one arm extended
laterally at the shoulder height. The subject applied max-
imal force upward against a wooden support, in which a
spring balance was attached and fastened to the floor. The
resulting correlations between movement speed and strength/
mass were non-significant, and the reliability coefficients

of individual differences for all variables were high. Clarke concluded that the ability to exert maximal strength in a coordinated manner is determined by specific neuromotor coordination patterns. No significant correlations were found between speed of movement and reaction time.

Mendryk (52) investigated reaction time, movement speed, and task specificity relationships at the ages of 12, 27, and 48 years in male subjects. The reaction time and movement speed of 150 subjects, 50 in each group, were recorded by Mendryk in 1960. The reaction time and movement speed was 12 percent faster in the 22 year old subjects than either the 12 or 48 year old groups. Individual differences exhibited 74 percent task specificity for short arm versus long arm movements, and 26 percent generality to move the arm quickly. The speed of reaction exhibited more task specificity than generality, but not as great as can be found with speed of movement.

Henry (38,39) completed two of his numerous investigations concerning specificity of reaction time and movement speed in 1961. One-hundred and twenty college males participated in Henry's (38) initial study in 1961. Each subject stood erect with his right arm extending laterally while resting on a reaction key. In response to an auditory stimulus, the subject swung his arm forward of 90 degrees at maximum speed to pass through a vertical pull-out target string placed an arm's length to his front. Each subject had 12 trials and the total arm distance moved was 117

centimeters. Reliability coefficients were .91 for reaction time, and .93 for movement speed. There was a .02 correlation between reaction time and movement speed, which led Henry to the conclusion that these abilities are independent and unrelated.

In the second investigation, Henry (39) studied stimulus complexity, movement complexity, age, and sex in relation to reaction latency and speed in limb movements. Four-hundred and two subjects of both sexes participated in the investigation. Reaction time and movement speed data of these subjects, who ranged in age from 8 to 30 years, were collected and analyzed by Henry. The correlations showed that the individual differences in reaction time and movement speed were almost entirely independent and unrealted. The correlations were low at every stage of motor development between the ages of 8 and 35 years for both sexes.

The specificity or generality of speed of systematically related movements was investigated by Lotter (48). Eighty college males were tested on a speed task of turning a two-handed arm crank, a similar movement using one arm involving closely the joint and muscle action of the two-armed movement, and also comparable movements of the legs. The correlations between single and repetitive arm movements were very low, as were the correlations between comparable leg movements. Significant correlations between total lower limb and total upper limb abilities were

present. Individual differences in speed ability were 85 percent specific and only 15 percent general.

Gray, Start, and Walsh (36) also investigated the relationship between speed of a limb movement and limb power in 1962. Sixty-two college students participated in the investigation and were tested on the ergometer and vertical power jump. The correlation between leg power and leg speed was .47. The correlation was low, and only accounted for 22 percent of the total variance. This result indicated a high degree of specificity and lower generality involved in these tasks. These results concur with those of Clarke (24) and also Henry and Whitley (42) concerning the individual differences between speed and strength of a limb movement.

Hodgkins (44) completed an investigation studying the relationship between reaction time and movement speed in relation to age and sex. Hodgkins concluded that (1) males have a faster reaction time and movement speed than females, (2) both the reaction time and movement speed increase in the individual until early adulthood and then decrease, (3) the peak movement speed is maintained longer by males and peak reaction time longer by females, and (4) that there was very low relationships between reaction time and movement speed in the majority of the groups studied.

Smith (64), Marteniuk (50), and Loockerman and Berger (47) completed the most recent studies concerning the specificity of movement speed and reaction time. Smith (64) completed an investigation in 1966 in which reaction

time and movement speed relationships of four large muscle
motor tasks were studied. Seventy males participated in the
study and performed four types of discrete movements: an
arm movement forward, backward, a leg movement forward,
backward. The reaction time and movement speed correlations
ranged from -.06 to .23, and none were statistically signif-
icant. The lowest reliability coefficient, when adjusted
by the Spearman-Brown Prophesy formula, was .93. Smith
concluded that individual differences in ability to react
quickly and move fast are almost entirely unrelated.

Marteniuk (50) investigated the degree of speci-
ficity or generality which exists in the learning and per-
formance of two similar speed tasks. Seventy-five college
students volunteered to participate in the study and were
tested on two simple stimulus-response type skills. Both
tests had common elements in that the movements consisted
of fast linear arm movements, requiring accuracy and fine
finger coordination. Each subject had 75 trials on the
speed tasks, the peg turn and the rho test. The peg turn
required the subject to lift his hand from a microswitch,
lift a wooden dowel from a block, turn it over with a
clockwise motion, and then return his hand to the micro-
switch. The rho test consisted of a clockwise movement of
a pivoted handle on a horizontal crank for one full rota-
tion. The learning score was computed by subtracting the
mean of the initial six trials from the mean of the last
six trials. The intertask correlation of learning was .29.

Only nine percent of the variance was held in common between the two tasks, therefore, Marteniuk concluded that the learning which occurred in the situation was specific to the task. This specificity of learning agreed with the findings of Bachman (22), Oxendine (53), Henry and Nelson (40), Singer (62), and Lempce (16).

Loockerman and Berger (47) completed a study in 1972 concerning the specificity of speed of movement and reaction time. They investigated the degree of specificity or generality found between forward, backward, left, and right directional movements of the dominant hand and total body under choice stimulus conditions. The subjects who participated in the study were 50 college freshmen. The results of Loockerman and Berger showed the generality of directions for reaction time of the hand to be between 39 and 52 percent, while the movement time was between 14 and 47 percent. The generality of directions for the total body for reaction time was between 36 and 55 percent, while the movement speed was between 6 and 22 percent. These findings led the researchers to the conclusion that the ability to react and move the dominant hand and total body appeared to be largely specific to the direction of the response.

Two studies concerning movement speed and reaction time were found to support the theory of generality rather than specificity. An investigation be Youngen (67), completed in 1959, compared the reaction time and movement speed of women athletes and women non-athletes. Forty-seven

women athletes and 75 women non-athletes participated in the investigation. The women athletes participated in the sports of swimming, fencing, field hockey, and tennis. After testing each subject on electronic apparatus utilized to measure reaction time and movement speed, Youngen found that women athletes showed a faster reaction time and movement speed that women non-athletes. Youngen also found low positive statistically significant correlations between reaction time and movement speed.

In the same year as Youngen's (67) investigation, Pierson (55) completed an extensive study of 400 male subjects ranging in age from 18 to 83 years. After testing each subject's reaction time and movement speed, Pierson found that at certain age levels the correlations between these two abilities were statistically significant. He referred to earlier investigations by Henry which showed no positive significant relationship between reaction time and movement speed. After examining Henry's findings, Pierson stated that there was considerable chance for error when conclusions concerning the entire population were drawn from a sample of male college students. The lowest correlations found by Pierson were in the range of -.20 to .20 for the college age group. He found correlations as high as .86 for the age group between the years 45 and 55; .82 coefficient for the ages between 40 and 45 years; and a .50 value at the age of 12 years. There was a .00 correlation at the age of 20 years.

In summary, the majority of research completed in the area of motor learning, concerning the question of specificity or generality of motor learning and performance, supports the task specificity theory. Perrin (54), Garfiel (34), Cozens (18), Hoskins (45), Jones (20), Freeman (33), Seashore (61), Gire and Espenschade (35), Cumbee, Meyer, and Peterson (30), Cumbee (29), Henry and Nelson (40), Fleishman (31), Bachman (22), Cratty (28), Fleishman and Ellison (32), Oxendine (53), Singer (62), and Lempce (16) completed studies supporting a high degree of specificity of both motor learning and motor performance. Robichaux (59) found results supporting the generality of motor learning. Lotter (48), Hipple (43), Slater-Hammel (63), Henry and Rogers (41), Henry and Whitley (42), Henry (37,38,39), Clarke (24), Mendryk (52), Gray, Start, and Walsh (36), Hodgkins (44), Smith (64), Marteniuk (50), and Loockerman and Berger (46) found low correlations between the speed of movement and reaction time of subjects of varying age levels. Some findings supporting a positive significant relationship between reaction time and movement speed were found by Youngen (67) and Pierson (55). However, the majority of findings supported the specificity theory.

Foot-eye Coordination and Tracking Skills

Since there are only a few instruments in existence which may be utilized to measure foot-eye coordination, there has only been a limited amount of research completed

in the area of foot-eye coordination and tracking skills.
The majority of these instruments are adaptations of hand-
eye coordination testing devices. This section of the
review of the literature will concern investigations in the
area of foot-eye coordination and tracking skills.

Fleishman (31) was one of the first researchers in
the area of motor learning to introduce instrumentation for
the sole purpose of testing foot-eye coordination.
Fleishman was concerned primarily with constructing various
tests of motor ability that could be useful to the Air Force
in training and screening potential pilots. In 1958,
Fleishman tested 204 basic trainees in the United States
Air Force on 31 individual tasks. Ten clusters of factors
resulted from the 31 tasks and 7 were named: response
orientation, fine control sensitivity, reaction time, speed
of arm movement, arm-hand steadiness, multiple limb coordin-
ation, and rate control. Two of the 31 tasks were foot-eye
coordination tests, and were referred to as rudder control
tasks. The reliabilities of these tasks were .70 for the
single target task and .82 for the triple target task. The
complex coordination task, which included both coordinating
movements of the hands and feet, correlated .40 with pilot
success.

Smith (17) utilized a tracing board to test the
foot-eye coordination of subjects in his investigation.
The subjects tested both their feet and hands in tracing a
diagram on the board. The results showed that 3 of the 10

correlations were significant in the hand-eye task, while 2
of the 10 correlations were significant in the foot-eye
coordination test. None of the significant correlations met
the .75 correlation level suggested by McCloy and Young (8)
as the minimum level for retention of a test for use in
testing physical skills.

Poulton (11) studied the literature concerning
tracking behavior and categorized tracking into five dis-
tinct types: pursuit, compensatory, acquisition or discon-
tinuous step function, unpaced contour, and paced contour
tracking. A description of these different types of
tracking is given below.

1. Pursuit tracking. Tracking in which the subject must
keep a marker or stylus in line with a moving target. A
pursuit rotor task is an example of this type of tracking.

2. Compensatory tracking. Tracking in which there is only
one moving element. The moving element tends to move away
from a fixed target. Fleishman (31) utilized a compensatory
task in testing Air Force personnel and referred to it as
the Single Dimension Pursuitimeter. The subject makes com-
pensatory adjustments (in and out movements) of a control
wheel, in order to keep a horizontal line in a null position
as it deviates from center in irregular fashion.

3. Acqusition or Continuous Step Function tracking.
Tracking which begins with the target and marker super-
imposed. During the task, the target suddenly jumps to a
different position and the subject must quickly change the

stylus position so it is superimposed on the target again. Fleishman (31) used a step function task and referred to it as the Control Adjustment task. Subjects are required to match the position of a red light with a green light in which they control. When the position is matched for a period of .5 second, the red light quickly changes to a new position. The subject must quickly superimpose the green light to this new position.

4. Unpaced Contour tracking. Tracking in which a contour is followed by a subject controlling a stylus at his own speed. An example of this type of tracking is star pattern mirror tracing.

5. Paced Contour tracking. Tracking in which the subject keeps a stylus in contact with a wiggly line approaching at a fixed speed. The marker moves across the approaching paper at right angles to the direction of the oncoming target. In both paced and unpaced contour tracking, the subject can observe the oncoming line at some distance in advance. This is the primary difference between contour tracking and pursuit tracking, in which there is no preview of the oncoming track. The ski simulator utilized in this investigation is an example of a paced contour tracking task.

Poulton (11) centers the majority of his review of tracking literature on the first three types of tracking: pursuit, compensatory, and step function tracking. Poulton notes that there have been few investigations completed

in the area of contour tracking and states:

> The two remaining kinds of tracking (unpaced and paced contour tracking) have received much less study. Both involve a target extended in space like a wiggly line. By far the commonest in everyday life can be called unpaced contour tracking (11:361).

Several aspects of the subject's performance are vital to tracking proficiency, one of which is pacing. Throughout the contour tracking task the subject must continually make movements of a specific size, but the size of the movements varies constantly. If the subject makes a correct movement, but at the wrong instant, it is as if he were to make an incorrect movement. The execution of the precise response at the correct instant is of the utmost importance in tracking skills.

Poulton (11) reported that a minimum of about .20 second is required for a man to respond to a visual stimulus. Welford supports this finding and states:

> If the track is hidden from view until it reaches the pen (stylus), the subject almost inevitably tracks a little late due to a reaction time between a stimulus entering the eye and the beginning of the response action, which represents the time taken by various sensory, central, and motor mechanisms to act (15:15).

Craik (25,26) found that subjects could not make error corrections at a rate faster than two per second. Even though paced contour tracking is a continuous task and the stimulus input is constantly changing, the output is discontinuous (Craik, 25,26). The psychological refractory period, which refers to a subject's delay in handling a

second of two successive signals which are closely spaced, was thought to be the reason for the discrete rather than continuous error corrections. Welford (15:15) states that the corrections "appear to represent the sum of a reaction time of about .3 second and a monitoring time of about .2 second.

Two sources of information can aid the subject in handling the reaction time delay according to Poulton (56). The subject must be able to determine the future position of the track, and this can be accomplished through either prediction or a display of the approaching track. Poulton states the importance of at least one of these factors as being present in a tracking task:

> If the track of the target is neither displayed ahead nor predictable, S's responses will tend to be at least one RT behind the target (56:472).

Poulton (11) has found that with pursuit tracking, when there was a future display of the target, there was an average reaction time lag of approximately zero. He found that a .4 second preview of the oncoming track was approximately as effective as an 8.0 second display. However, when the preview was decreased to .3 second, there was a significant reaction time lag and decrement in performance. Concerning contour tracking, Poulton states:

> In contour tracking, where he can see the track ahead, he has simply to reproduce the track as he sees it one reaction time ahead of his response indicator, which he can do reasonably well (11:391).

Prediction can also greatly aid the subject in decreasing his errors in tracking tasks. Adams (21), after reviewing tracking literature, has found that motor performance and tracking can benefit from predictor responses. Prediction can be based upon the track's regularities or the visible rate of the track. Both the display of the track and prediction of the track may be very helpful to the subject. At least one of these factors is vital in high frequency tracking, in which the reaction time lag is most detrimental.

With paced contour tracking, the type of tracking utilized in ski simulation, a preview of the track is provided and the course is predictable. In referring to this type of tracking, Poulton states:

> When he can see the wiggly line sufficiently far ahead, he tends to aim first at one bend and then at the next. If he has time, he may correct himself when he badly overshoots or undershoots at a bend. But he tends not to worry too much about his error between the bends (11:390).

The ski simulator is unlike most paced contour tracking tasks due to the fact that the wiggly line may not be followed exactly by the subject's stylus with no decrement in performance. Most investigators measure the subject's time on target, and any deviation from this line is recorded as time off target or an error score. Subjects tested on the ski simulator must be concerned primarily with the position of the stylus at the bends (ski gates), but small deviations between the bends may not be detrimental to the subject's performance. However, at fast

speeds of the simulator, precision between the bends becomes vital.

A subject's performance on tracking tasks may be affected by physiological factors such as fatigue, or by psychological responses such as vigilance. Vigilance is associated with a loss of alertness due to a long period of continuous work under low stress conditions. Mackworth (49:209) states that "performance in vigilance tasks undergoes a decrement as the task continues, and adds:

> that continuous concentration upon one aspect of the enviornment leads to a decreased ability to perceive particular changes in that aspect. The decrement may be due to either increased internal "noise" or to decreased sensitivity (49:210).

After studying active and passive tasks in which continuous attention is required, Broadbent (23) suggested that automatic shifts of attention may occur and may also lead to decrements in performance. Welford (15) has found that these decrements in performance on vigilance tasks may be associated with drowsiness or lack of interest.

As with other motor learning tasks, fatigue can produce a decrement in performance on tracking skills. Fatigue is usually associated with tasks of long duration in which the subject is working under high stress conditions. Fitts and Posner (4) suggest that tracking skills under high stress conditions usually will show improvements in performance due to learning. However, concerning highly skilled performers on a continuous task, Fitts and Posner state:

> However, if the subject is already highly
> skilled, efficiency will decrease the longer
> the task is continued, and the decrease is
> attributable to fatigue (4:38).

As Poulton (11) has indicated, paced contour tracking tasks are the least studied tracking skills. The researcher has found a limited number of investigations in which paced contour tracking was used. Whitley (66), and Straub (65) have utilized instrumentation which have not been reported to have been used in any previous studies. Roth (60), Crancer (27), and Rafaelsen (58) utilized simulated driving apparatus to test the effects of alcohol and marijuana on driving performance. None of the three investigations using simulated driving apparatus reported reliabilities of the instrumentation. Whitley (66) and Straub (65) specifically used instrumentation to test foot-eye coordination.

Whitley (66) completed an investigation in 1969 using a new motor learning task referred to as the foot-twist tracking task. Sixty college males participated in the study and were given 35, 1 minute trials. Each trial consisted of a 30 second work period and a 30 second rest period. Each subject was seated in a chair with his right foot secured in a foot piece. The subject could freely rotate his lower leg at the knee joint. A stylus was attached to the foot piece and during the testing the subject attempted to keep a stylus in contact with the target. The target consisted of an irregular smooth curve that was drawn on a rotating drum located at the subject's

right foot. The results of the investigation showed that the amount of learning on the task was significant, but less than that on pursuit rotor tests or large muscle coordination tests such as the Bachman ladder climb. The reliabilities, on the other hand, were relatively high, .77.

Straub (65) completed the only investigation in which the ski simulator was utilized to test the foot-eye coordination of skiers and non-skiers. The testing device utilized in Straub's investigation was the same apparatus used in the present study. The subjects who participated in the study were 80 females ranging in age from 18 to 26 years. The subjects comprised 4 equal groups of 20: non-skiers (N=20), beginners (N=20), intermediates (N=20), and advanced skiers (N=20). Demographic data and ski experience data were collected by Straub prior to the experimental testing. The ski experience in years for the three skiing groups was: advanced, 10.75 years; intermediate, 4.80; and beginners, 1.95 years. The average ski days per year for these three groups was: advanced, 23.45 ski days; intermediate, 9.10 ski days; and beginners, 3.15 ski days per year.

Straub hypothesized that the ski simulator would discriminate between skiers and non-skiers, and that it would also classify skiers as to their proficiency levels. Subjects were given a practice trial at a speed of 6 rpm. and then tested at the test speeds designated as slow (6.5 rpm.), medium (7 rpm.), and fast (7.5 rpm.) A one

minute rest period was given between trials. As the belt speed increased, the error scores of each group of skiers also were greater. Statistically significant differences were found in foot-eye coordination for each group of skiers across the three simulation speeds. Error scores for the advanced skiers on ski simulation were 4.20 (slow speed), 6.80 (medium), and 8.25 (fast); for intermediate skiers: 3.50, 9.35, and 14.90; for beginner skiers: 5.80, 13.20, and 15.85; and for non-skiers: 7.55, 13.45, and 19.75. The advanced skiers made the least number of errors at medium and fast speeds, while the intermediate group showed the least amount of errors at slow speed. Straub indicated that this lower error score by the intermediate group, and the greater error score of the advanced group on slow speed, may have been due to a lack of concentration or vigilance effect on the subjects' performance in the advanced group of skiers. Significant differences in foot-eye coordination were found at medium (.05 level) and fast (.01 level) speeds of the ski simulator between the four groups of subjects. However, there was no statistically significant difference in foot-eye coordination found between the four groups of skiers at slow simulation speed. Therefore, Straub con- cluded that the ski simulator was a valid instrument for testing skiing proficiency when operated at either medium or fast speed.

Chapter 3

PROCEDURES

The contents of this chapter will explain the procedures undertaken in this study. The ski simulator has not been reported to have been used in any previous study concerning the measurement of foot-eye coordination. A description of the machine is necessary to familiarize the reader with the apparatus. A blue print, or design of the study, must be formulated prior to the data collection. This chapter's contents consist of a description of the population and sample, sources of the data, the design of the study, instrumentation, and method of data collection, and organization of the data for statistical treatments.

Description of the Population and Sample

Sixty male subjects volunteered to participate in the investigation. Forty-nine of these subjects were part of the total undergraduate population of 3,700 students enrolled at Ithaca College during the Spring semester of 1973, while the remaining 11 subjects planned to enter college in the Fall of 1973. These 60 subjects ranged in age from 17 to 25 years and had a mean age of 20.69 years.

The 60 subjects were divided into 2 equal groups of 30 persons, according to their skiing ability. Group I, Non-skiers, consisted of 30 students who had no previous experience in the sport of skiing prior to their testing date on the ski simulator. Group II, Skiers, consisted of 30 college students who had skied for at least 3 years prior to their testing on the ski simulator. These students skied regularly as time, money, weather conditions, and other factors permitted. The researcher assumed that after three years of skiing, their performances were of at least average skiing competency.

Sources of the Data

Three sources of information were collected by the researcher: demographic, experimental, and reliability data. Prior to the testing on the ski simulator, all subjects completed a questionnaire (Appendix). Each subject recorded his age, height, weight, and information concerning his skiing experience.

The second source of information, the experimental data, was the actual results of each subject's performance on the ski simulator. Each subject was tested on the ski simulator at three different speed levels: slow, medium, and fast. The ski simulator recorded automatically the gates missed by the subject throughout the trial, and these data were referred to as the subject's error score.

The final source of information collected by the

researcher was the reliability data. Eight subjects from each group, the Non-skiers and the Skiers, were randomly selected and retested on the ski simulator during the third week after their initial trials. Product-moment correlation coefficients were calculated on the RCA Spectra 70/35 computer at Ithaca College.

Design of the Study

The two groups of subjects who participated in the investigation were known to differ on the criterion measure, skiing performance. Group I, Non-skiers, had not skied prior to their testing on the ski simulator. Group II, Skiers, had skied at least three years prior to their testing on the ski simulator. The ski experience of Group II, Skiers, was the experimental treatment or variable which was thought to bring about changes in foot-eye coordination. Therefore, the study was ex-post facto in nature, that is to say, pretests could not be given since the experimental treatments had already taken place. Consequently, a posttest was given to measure the effects of the experimental treatment.

Both groups of subjects were tested under controlled conditions, and their error scores (gates missed) were compared statistically. The .05 level of significance was utilized for rejection of the null hypothesis.
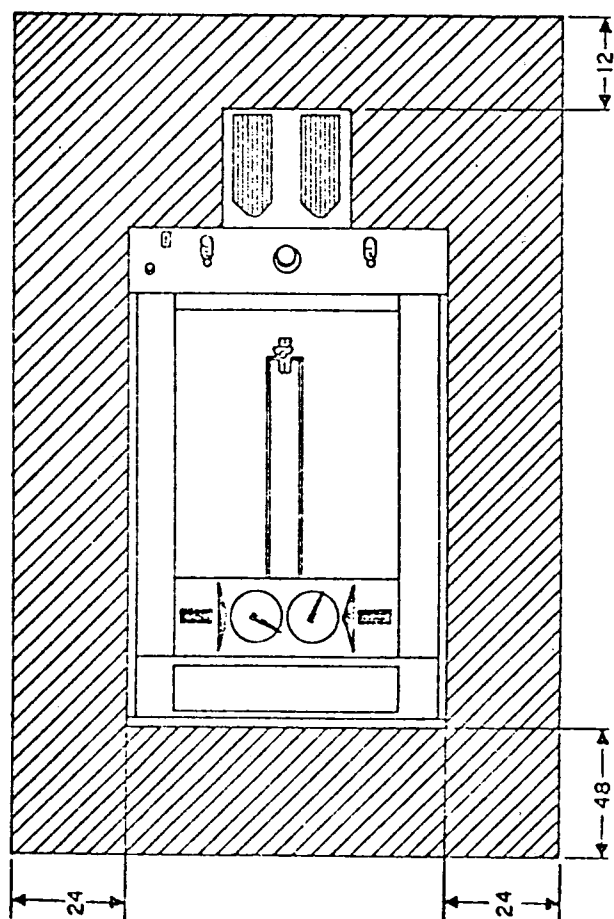
Instrumentation

The ski simulator, Dukane Model 14A635, was uti-

lized as the testing device in the experiment. Shown in Figure 1 are overhead and front views of the ski simulator, while the rear and side views of the appartus are illustrated in Figure 2.

In the testing position, the subject was required to stand on two parallel pedals; two inches apart and seven and one-half inches from the base of the appartus. The subject placed his hands on two upright poles located directly in front of him. The subject directed his vision downward to an enclosed area, 44 inches in length and 37 inches in width, slanting downward at an approximate angle of 45 degrees. This enclosed area was approximately four feet in height. A piece of clear plastic covered the top surface.

Directly under the plstic covering was located a simulation of a man on skies, approximately two inches in height. The simulated skier was manipulated to turn 45 degrees to the right or left by the corresponding foot movements of the subject on the pedals. The simulated skier was situated above a rotating belt, which was two and one-half feet in width. Attached to the revolving belt were four strips of metal located one foot apart. Each metal strip extending across the belt had a small two inch opening, or gate. The belt revolved 20 times to complete a trial.

The object of the test was for the subject to manipulate the simulated skier through these gates by

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SLOPE LAMP

PENALTY INDICATOR

PENALTY INDICATOR

TOTAL SCORE INDICATOR

SKIER FIGURE

SLALOM INDICATOR

37 1/4"

57

FRONT VIEW

OVERHEAD

12

48

24

24
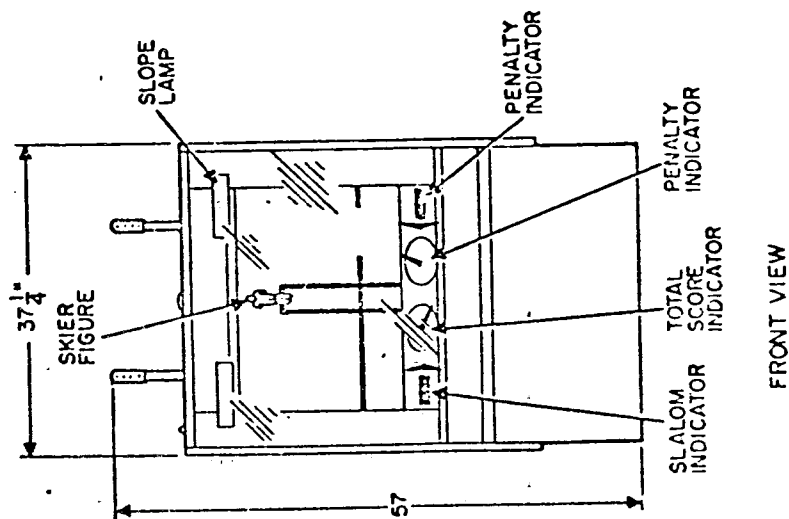
NOTES:
1. ALLOW 138 BY 85 CLEAR FLOOR SPACE FOR MACHINE.
2. ALL DIMENSIONS IN INCHES.

Figure 1
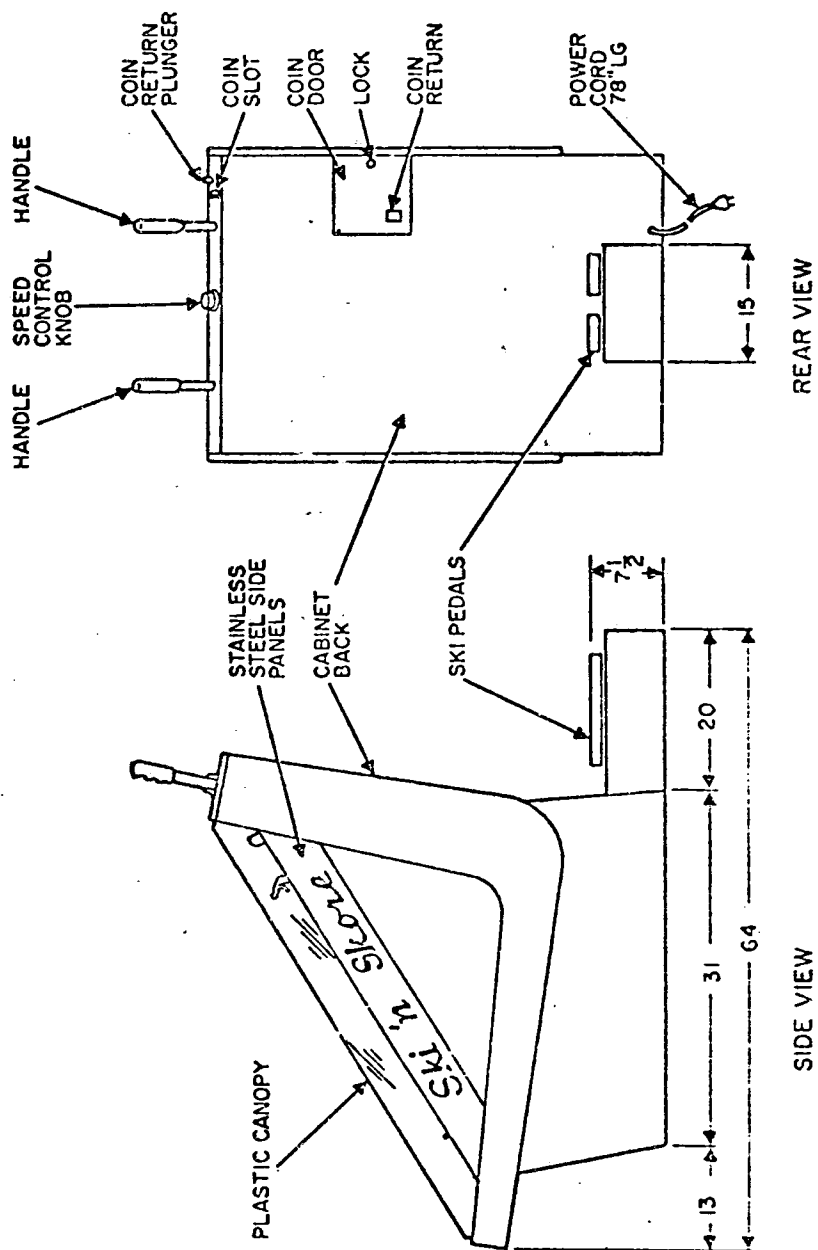
The Ski Simulator: Overhead
and Front View

Figure 2

The Ski Simulator: Side View
and Rear View

his corresponding foot movements on the pedals. If the simulated skier touched a metal strip with any part of his skies, it was recorded as a missed gate. The subject's error score was equal to the number of missed gates throughout the test. Each trial was completed after the subject guided the simulated skiers through the 80 gates.

Method of Data Collection

The ski simulator was situated in the motor learning laboratory on the ground floor of the Science building at Ithaca College. One subject was administered the test at a time. No one was present except the test administrator and the subject being tested. The investigator taped the following instructions on a tape recorder and each subject listened to them prior to his testing on the ski simulator.

> The device you are about to be tested on is called a ski simulator. It is being utilized to test foot-eye coordination. Two groups of subjects are being tested; skiers and non-skiers. The researcher is interested in finding whether skiers perform better than non-skiers on this instrument.
> The subject will now take the starting position, standing on the two pedals and grasping the ski poles located directly in front of you. The simulated skier will move to the right or left depending upon your corresponding foot movements on the pedals. The object of the test is for you to manipulate the skier through the openings on the belt. There are metal strips extending across the belt with two inch openings. If the skier touches these metal strips, it is recorded as a missed gate by the simulator. The number of missed gates throughout the test will be referred

to as the error score. The most important point to remember in obtaining the lowest possible error score is to manipulate the simulated skier so that it is directed to the oncoming gate before completing the exit through the current gate. You will be given one practice trial at a slow speed of six, and then will be tested at three different speed levels. These speeds will be designated as slow, six and one-half; medium, seven and one-quarter; and fast, eight. There will be a one minute rest period between each trial, in which you will be seated. If there are any questions, please ask them prior to the start of the actual testing.

After the subject listened to the instructions, he was given a practice trial at a moderately slow speed of six. Following this practice trial, the subject was tested once at three different speed levels: slow, six and one-half; medium, seven and one-quarter; and fast, eight. Between each trial the subject was seated for a rest period of one minute. If the subject had any questions, he was requested to ask them prior to the actual testing.

Organization of the Data

The scores of the practice trial for each subject were not recorded. Each subject had one trial at each of the three different testing speeds, and these scores were recorded by the researcher. Following data collection, the error scores were placed on data sheets so that key punching could be performed. Data were then key punched and verified. Data processing then began.

Data Analysis

A tally statistics computer program was utilized to obtain means and standard deviations for each group on each variable, e.g., demographic data (age, height, weight, and skiing experience) and experimental data (error scores). The separate variance t model was utilized to find the value of t for each of the demographic variables of age, height, and weight. A two-tailed t-test program was utilized to determine if statistically significant differences existed (.05 level) between the groups on these three demographic variables.

In making the choice as whether to use the one-tailed or two-tailed t test in comparing the results of the two groups of subjects, the researcher consulted Popham (10:56):

> When the researcher does not make a prediction
> he allows for the possibility of a statistical
> result which may either be positive or negative.
> Hence he must use a two-tailed test to interpret
> his results.

Therefore, a two-tailed test was utilized due to the fact that the researcher did not make any predictions regarding the results of the demogrpahic variables.

The assumptions underlying the use of the t test are that the population sampled is normal, and that the sample has been drawn randomly from the population. The failure to utilize random sampling procedures is the major limitation of this investigation. Volunteer subjects participated in the study rather than subjects selected

randomly from the population. Although the use of a random sample is of extreme importance when inferential statistical procedures are utilized, Tate (14:11) states the value of research lacking randomization:

> However, it would be incorrect to conclude that the study of a nonrandom sample is without significance. The investigation may be worthwhile, both because the sample evidence may be important in itself and because the investigation may suggest significant problems and hypotheses for more extended and general study.

The experimental data were run on the RCA Spectra 70/35 computer at Ithaca College. F ratios were computed for each group of subjects on each variable, and the F distribution table was referred to in order to find out if the F ratios were statistically significant. A multiple discriminant function program was utilized to test for overall difference in foot-eye coordination among the two groups of subjects. Multivariate statistical procedures enabled the researcher to avoid the practice of a single variable at a time comparison, and to answer the basic question of whether or not the two groups of subjects differed significantly in foot-eye coordination when all three speeds were considered.

To test the reliability of the ski simulator, eight subjects from each group were randomly selected and retested during the third week after their initial trials. The initial and posttest scores were then utilized to produce product moment correlation coefficients for each

experimental variable. The statistical significance of the coefficients were determined by consulting the appropriate table.

Chapter 4

RESULTS

Three sources of data were collected by the researcher. Prior to each subject's testing on the ski simulator, he completed a questionnaire (Appendix A) in which he recorded his age, height, weight, and information concerning his skiing experience. The researcher will present these data in the first section of this chapter.

The second source of data, the ski simulation results, will be presented in the second section of this chapter. Each subject was tested at three different speed levels on the ski simulator: slow, medium, and fast. The results of descriptive and inferential statistical procedures, along with graphical and tabular analyses, will also be presented in this section.

In the final section of the chapter reliability data will be presented for the ski simulator. Eight subjects in each group, the Non-skiers (Group I) and the Skiers (Group II), were retested on the ski simulator during the third week after their initial trials were taken. During retesting, the same initial testing procedures were utilized. Each subject was given a practice trial on the ski simulator at the speed of six. Each

subject was then tested at the speeds of six and one-half (slow), seven and one-quarter (medium), and eight (fast). One minute rest periods were observed, in which the subject was seated, between each trial at the various speeds during the testing. The product moment correlation coefficients between the original test scores and the retest scores for each group, at the three different speed levels, were calculated by the researcher.

Demographic Data

The mean raw scores, standard deviations, and t-test values for Non-skiers and Skiers for demographic variables are shown in Table 1. As shown, the two groups of subjects were very similar in age, height, and weight. No statistically significant differences were found between Non-skiers and Skiers on any of the demographic variables.

Table 2 shows the mean raw scores and standard deviations for the number of years of skiing experience for the Skiing group. Subjects in Group I, the Non-skiers, had no previous experience in the sport of skiing prior to their testing on the ski simulator. Therefore, only the results for the Skiers are shown in Table 2.

Each subject in Group II (Skiers) and Group I (Non-skiers) listed his current field of study at Ithaca College. These data were tabulated by the researcher and are shown in Table 3. Five students in Group II and six subjects in Group I entered college in the Fall

Table 1

Demographic Data for Skiers
and Non-skiers

Variable	Group I (Non-skiers) (N=30)		Group II (Skiers) (N=30)		
	X	S.D.	X	S.D.	t
Age	21.20	2.30	20.17	1.66	1.99
Height	70.40	3.13	69.80	2.86	0.22
Weight	163.77	15.95	162.57	25.71	0.76

d.f.=29

Table 2

Skiing Experience for Skiers

Variable	$\overline{X}$	S.D.
Ski Experience(yrs.)	6.57	3.66
Ski Days per Year	14.83	17.91
Ski Days in Winter of 1972-73	11.77	22.28
Ski Lessons with a Certified Instructor	2.63	3.01

of 1973. Therefore, no field of study was recorded for these students. As shown, the majority of subjects who participated in the study were physical education majors. Ten óf the 30 subjects in the Non-skiing group and 5 participants in the Skiing group were majoring in physical education. Fifteen other fields of study were represented by participants in this investigation.

Of the 30 skiers in Group II, only 5 reported sustaining injuries serious enough to consult a physician. Two of these injuries were lacerations caused by being cut by a ski pole. The two most serious injuries reported to the researcher were a fracture of the lower leg and a low back strain. As shown in Table 4, both injured skiers had the least skiing experience and were skiing on the most difficult slope at the time of injury. Table 4 also shows that all of the subjects reported having taken some skiing lessons with a certified instructor except one of the two skiers who was seriously injured.

Ski Simulation Data

Each subject in Group I (Non-skiers) and Group II (Skiers) was tested on the ski simulator at three different speed levels: slow, medium, and fast. A practice trial at a slow speed designated as six on the ski aimulator was given prior to the actual testing. The designated speed level of the ski simulator for the actual test speeds was slow, six and one-half; medium, seven and one-quarter, and fast, eight. The researcher recorded the number of missed

Table 3

Field of Study: Major in College
for Non-skiers and Skiers

Field of Study	Non-skiers (N=30)	Skiers (N=30)
Entering College in Fall of 1973	6	5
Physical Education	10	5
Physics	0	1
Undecided	1	3
General Studies	1	1
Biology	0	1
Television & Radio	2	2
Business	3	4
Math	2	1
Sociology	0	1
Health Administration	0	2
Philosophy	0	1
Politics	3	1
Psychology	0	1
Economics	0	1
Physical Therapy	1	0
History	1	0

Table 4

Ski Injuries for Group II (Skiers)

Skiers Injured	Type of Injury	Body Part Injured	Ski Experience at Time of Injury	Slope Injured on	Ski Lessons
1	laceration	facial	12 years	expert	6
1	laceration	facial	4 years	intermediate	5
1	fracture	lower leg	2 years	expert	5
1	strain	lower back	2 years	expert	0
1	sprain	ankle	2 years	intermediate	5

gates during each trial for each of the 30 subjects in both groups, the Non-skiers and the Skiers.

The mean error scores for Non-skiers and Skiers on ski simulation are graphically illustrated in Figure 1. It can be seen that the error scores of the Skiing group are much less than the error scores of the Non-skiing group at the three different speed levels of the ski simulator.

Table 5 shows the mean error scores, standard deviations, and F values for the Skiers (N=30) and Non-skiers (N=30) on ski simulation. As shown, a statistically significant difference (.05 level) was found to exist between the mean raw error scores for Non-skiers (Group I) and Skiers (Group II) at all three simulation speed levels. As shown, the Skiers outperformed the Non-skiers at each speed level.

Three minor null hypotheses were stated in this investigation. A statistically significant difference (.05 level) was found to exist between the Skiers and Non-skiers when the ski simulator was operating at slow speed. Group II (Skiers) outperformed Group I (Non-skiers) at the slow speed of the ski simulator. Therefore, the first minor null hypothesis was rejected. There was a statistically significant difference (.05 level) in foot-eye coordination between college Non-skiers and college Skiers when the ski simulator was operating at slow speed.
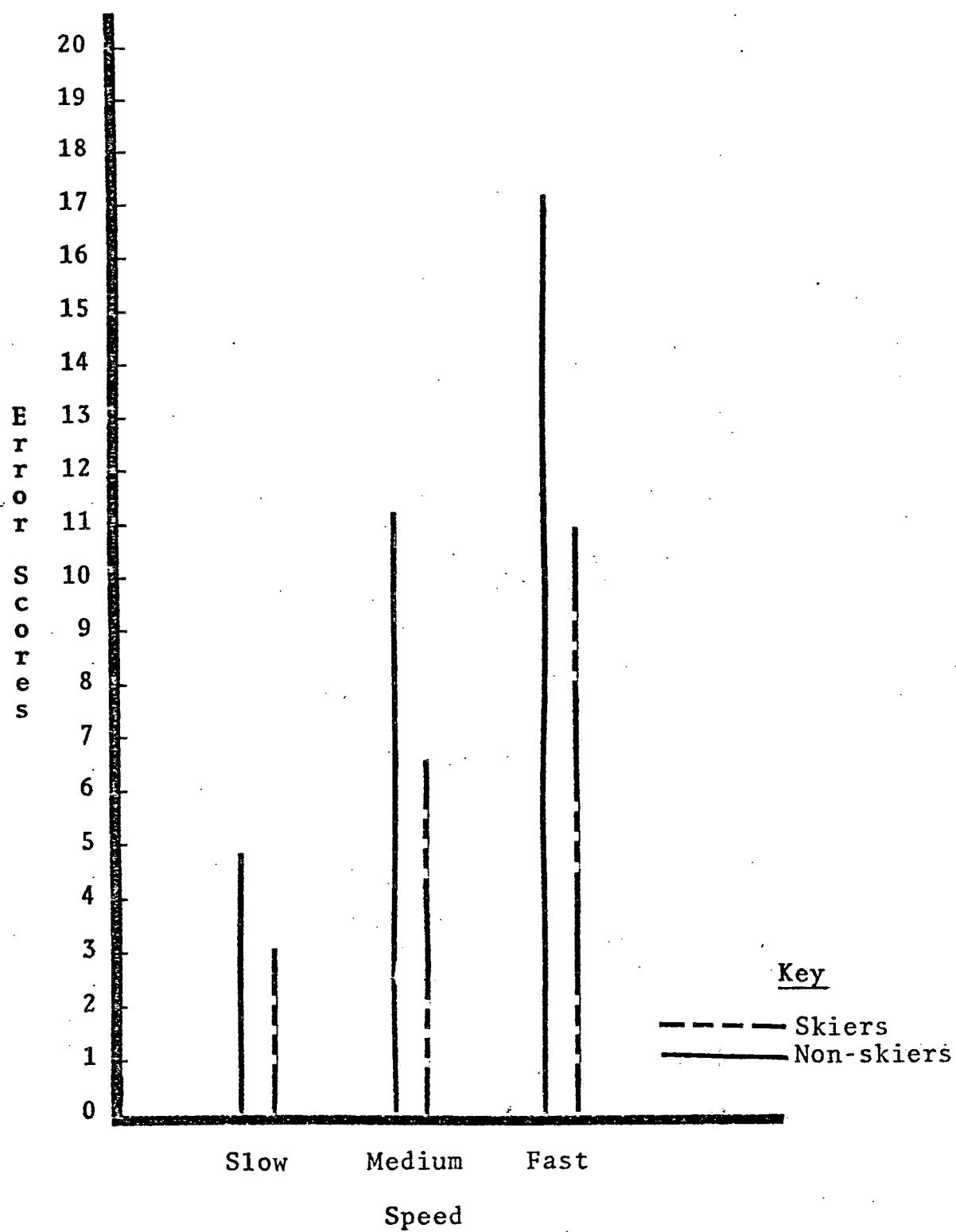
Figure 3

Mean Error Scores for Non-skiers and Skiers
on Ski Simulation

Table 5

Mean Error Scores, Standard Deviations, and F
Values for Non-skiers and Skiers
on Ski Simulation

Speed	Non-skiers (N=30)		Skiers (N=30)		
	$\overline{X}$	S.D.	$\overline{X}$	S.D.	F
Slow	4.87	2.86	3.07	2.60	6.50[b]
Medium	11.27	3.59	6.57	2.65	33.29[a]
Fast	17.23	6.71	11.03	3.57	19.95[a]

[a]Significant beyond the .01 level with d.f.= 1&58.
[b]Significant at the .05 level with d.f.=1& 58.

A statistically significant difference (.01 level) was present between the Non-skiers and the Skiers when the ski simulator was operating at both the medium and fast speeds. The Skiers had lower mean error scores at both simulator speed levels. It was concluded, therefore, that they possessed better foot-eye coordination than the Non-skiers at medium and fast speeds. As a result of these analyses, both the second and third minor null hypotheses were rejected. There was a statistically significant difference between the college Skiers and the college Non-skiers in foot-eye coordination when the ski simulator was operating at medium (hypothesis 2) or at fast (hypothesis 3) speed.

Table 6 shows the results of multiple discriminant function analysis of ski simulation variables for Skiers and Non-skiers. As shown, the Wilks' Lambda criterion was found to be statistically significant beyond the .0001 level. In addition, Mahalanobis D^2 statistic, a distance measure, also reached statistical significance beyond the .001 level. Therefore, it was concluded that the Skiers possessed significantly better foot-eye coordination than the Non-skiers. The results, shown in Table 6, failed to support the major null hypothesis which stated: There will be no statistically significant difference in foot-eye coordination of college Skiers and college Non-skiers as measured by the ski simulator.

Table 6

Multiple Discriminant Function Analysis
of Ski Simulation Values for
Skiers and Non-skiers

Wilks' Lambda	d.f.	F	D^2	d.f.
0.601	3 & 56	12.38[a]	29.26[a]	3

[a]Significant beyond the .0001 level.

Table 7 shows the discriminant score weights for Skiers and Non-skiers on ski simulation. As shown, the .889 value for the medium speed contributed the most to the between-groups variance. That is to say, when the machine was operated at medium speed, it was found to be the best predictor of foot-eye coordination between Skiers and Non-skiers. A -0.407 value was found for slow speed of the ski simulator. This negative discriminant score weight indicated that the ski simulator, when operated at slow speed, is not a good predictor of foot-eye coordination.

Reliability Data

The final section of this chapter concerns the reliability of the ski simulator. Eight subjects in each group, the Non-skiers (Group I) and the Skiers (Group II), were retested on the ski simulator the third week after their initial test. Each subject was given a practice trial at a speed of six, and then was retested at the identical speed levels at which he was initially tested. These speeds were slow, six and one-half; medium, seven and one-quarter; and fast, eight. The test-retest correlation program was run on the RCA Spectra 70/35 computer at Ithaca College.

Product-moment correlation coefficients for slow, medium, and fast speeds on the ski simulator for Non-skiers (Group I) are reported in Table 8. As shown, two of the correlation coefficients were found to be statisti-

Table 7

Discriminant Score Weights for
Non-skiers and Skiers on
Ski Simulation

Simulated Speed	Axis I
Slow	-0.407
Medium	0.889
Fast	0.211

cally significant beyond the .01 level. The only cor-
relation coefficient that failed to reach statistical
significance (.05 level) was at slow speed for the Non-
skiing group.

Shown in Table 9 are the product-moment cor-
relation coefficients for the Skiing group (Group II) at
the three different speed levels of the ski simulator.
The reliability of the ski simulator for Skiers at the
three different speeds was high, .79 to .92. A reliability
of .92 at slow speed was found to be statistically signifi-
cant beyond the .01 level. At medium and fast speeds,
the reliability was found to be .79 and .83 respectively.
These values were found to be statistically significant
at the .05 level.

Table 8

Mean Error Scores, Standard Deviations, and Product
Moment Correlations for Slow, Medium, and Fast
Speed on the Ski Simulator for Non-skiers

Group I (n=8)					
Speed	$\overline{X}$	S.D.	$\overline{X}$	S.D.	r
Slow	4.75	1.49	3.00	1.41	0.14
Medium	12.87	3.48	10.63	3.75	0.87[a]
Fast	14.75	7.00	14.75	6.58	0.90[a]

[a]Significant beyond the .01 level with d.f.=
6.

Table 9

Mean Error Scores, Standard Deviations, and Product
Moment Correlations for Slow, Medium, and Fast
Speed on the Ski Simulator for Skiers

Group II(n=8)					
Speed	$\overline{X}$	S.D.	$\overline{X}$	S.D.	r
Slow	1.87	2.36	2.00	1.85	0.92^a
Medium	5.87	2.03	6.00	1.77	0.79^b
Fast	10.29	3.24	10.13	3.18	0.83^b

[a]Significant beyond the .01 level with d.f.=
6.
[b]Significant at the .05 level with d.f.=6.

Chapter 5

DISSCUSSION OF THE RESULTS

Three sources of data were reported by the researcher in Chapter 4 of this investigation. These data included demographic variables concerning each subject's height, weight, age, and skiing experience; ski simulation data; and reliability data. Although hypotheses were formulated concerning the ski simulation data only, significant aspects of the demographic and reliability data will be discussed in this chapter.

Demographic Data

The mean raw scores for the Non-skiers (N=30) and the Skiers (N=30) for age, height, and weight variables were found not to be statistically significant. The subjects ranged in age from 17 to 25 years. However, the majority of participants in the investigation were of college age, between 18 and 22 years. There was a difference in age of 1.03 years between Skiers and Non-skiers. Since the subjects volunteered to participate in the investigation, the close relationship of height and weight variables between Group I (Non-skiers) and Group II (Skiers) occurred by chance.

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In a similar investigation completed by Straub (65), 80 females between the ages of 18 and 26 years were tested on the ski simulator. Straub reported no statistically significant differences (.01 level) for height, weight, and age variables between the four groups of subjects. Straub's subjects were classified according to their levels of skiing performance: advanced (N=20), intermediate (N=20), beginner (N=20), and non-skiers (N=20).

Subjects in Group I, Non-skiers, had no previous experience in the sport of skiing prior to their testing on the ski simulator. Only ski experience data of Group II, Skiers, were recorded. Therefore, no hypotheses were made by the researcher concerning the differences in ski experience variables between Skiers and Non-skiers.

The standard deviations for three of the skiing variables are greater than the mean raw scores reported in Table 2 (Chapter 4). These three variables are Ski Days per Year ($\bar{x}$=14.83, S.D.=17.91); Ski Days in Winter of 1972-73 ($\bar{x}$=11.77, S.D.=22.28); and Ski Lessons with a Certified Instructor ($\bar{x}$=2.63, S.D.=3.01). The mean describes central tendency, while the standard deviation represents variability from the mean. There are two primary reasons for the occurrence of the larger standard deviations than means in these instances.

The first reason for the occurrence of a larger standard deviation than the mean raw score on the three variables is referred to as the skewness of the distri-

bution. All three of these variables have a disproportionately large number of values at one end of the distribution. For the variable Ski Days per Year, 20 of the subjects in Group II (N=30) said that they averaged less than 10 ski-days per year; 9 skiers noted that they skied between 10 and 30 days; while 1 skier reported that he averaged 100 ski-days per year. The other two ski experience variables showing greater standard deviations than mean raw scores, Ski Days in Winter of 1972-73 and Ski Lessons with a Certified Instructor, showed a similar arrangement of values as was the case with Ski Days per Year.

There may also have been a second reason for a greater standard deviation than for mean raw scores on these three variables. This may have been due to the small sample size of Group II (N=30) in the investigation. With the use of a larger sample size, the extreme score at one end of the distribution would not have affected the standard deviation as much as it did in this study.

Ski Injuries

Ski injuries may be caused by several different factors, e.g., poor skiing conditions, an excessive number of skiers on the slope, improper or faulty equipment, and physiological factors such as fatigue. As reported in the Encyclopedia of Sport Science and Medicine, beginner skiers were involved in 55 percent of all ski injuries. However, the beginner accounts for only 21 percent of those individuals

who ski. The injury rate for the beginner was 5 times greater than for the experienced skier, i.e., 16.0/1000 ski-man days as compared to 2.9/1000 ski-man days respectively.

Five of the 30 skiers suffered injuries in which it was necessary to consult a physician. The two most serious of the five injuries, a fracture of the lower leg and a lower back strain, occurred to skiers while skiing on the expert slope in only their second year of experience in the sport. No hypotheses were formulated or conclusions drawn concerning ski injuries due to the nature of the study and the limited ski injury data available. However, ski injury data in these two instances indicate that inexperienced skiers may have overestimated their capabilities. Further investigations concerning ski injuries may show the need for the development of a test, such as the ski simulator, to categorize skiers into competency levels. Inexperienced or beginning skiers may be prohibited from skiing on slopes above their competency level to prevent injuries to themselves or other skiers.

Ski Simulation Data

The major question to be answered in the present investigation was whether the ski simulator could discriminate between skiers and non-skiers. After testing each subject in Group I (Non-skiers) and Group II (Skiers) at each of the three speed levels (slow, 6.5 rpm.; medium, 7.25 rpm.; and fast, 8.0 rpm.), it was found that the ski simulator did discriminate between the groups. A statistically

significant difference at the .05 level existed at slow speed, and beyond the .01 level at both medium and fast speeds of the ski simulator. Thus, the results failed to support the null hypothesis which stated: There will be no significant difference in foot-eye coordination of college skiers and college non-skiers as measured by the ski simulator.

In comparing these results to those of Straub's, it can be seen that similar findings are present. Straub found statistically significant differences among the four groups of female subjects (advanced, N=20; intermediate, N=20; beginner, N=20; and non-skiers, N=20) in foot-eye coordination, except at slow speed of the ski simulator. A statistically significant difference in foot-eye coordination existed at the .05 level at medium speed, and beyond the .01 level at fast speed between Straub's groups of subjects. A statistically significant difference was not found at the slow simulation speed, and Straub concluded that this may have been due to the fact that the advanced skiers appeared to be bored at the slow simulation speed. Although there was a statistically significant difference found between Skiers and Non-skiers at slow speed (.05 level) in the present investigation, the level of significance was not as great as found at both medium and fast speeds (.01 level).

In this investigation there was a statistically significant difference beyond the .01 level at both medium

and fast simulation speed levels. The .01 level of signif-
icance was only reached at the fast simulation speed in
Straub's investigation, while a statistically significant
difference at the .05 level was found at medium speed. Due
to the statistically significant difference at the .01 level
at fast simulation speed found between groups in Straub's
investigation, he concluded that the ski simulator should be
operated at fast speed when performance tests are utilized
for classification purposes. In the present investigation,
when discriminant score weights were calculated for Skiers
and Non-skiers, a .889 value was found at medium speed. It
was concluded that when the ski simulator was operated at
medium speed, it was found to be the best predictor of foot-
eye coordination between Skiers and Non-skiers.

The primary reason for Straub's conclusions that the
fast speed was a better discriminator of skiing competency,
and the results of the present investigation favoring the
medium speed, may have been due to the difference in simu-
lator speed (rpm. level) in the two studies. In Straub's
study the ski simulation speed levels were slow, 6.5 rpm.;
medium, 7.0 rpm.; and fast, 7.5 rpm. In this investigation
the speed levels were slow, 6.5 rpm.; medium, 7.25 rpm.; and
fast, 8.0 rpm. Thus, there was only a .25 rpm. difference
between Straub's fast speed (7.5 rpm.) and medium speed
(7.25 rpm.) in this study. There was a larger difference
(.5 rpm.) between the fast speeds in the two investigations,
7.5 rpm. in Straub's study and 8.0 in this investigation.

The 8.0 rpm. speed in this investigation proved to be very difficult for even the Skiing group. The increase in mean error score (4.46) was the largest increase from one speed to the next for the Skiers. Thus, the simulation speed of 7.25 rpm. (medium) in this investigation and the speed of 7.5 rpm. (fast) in Straub's study were found to be the best predictors of foot-eye coordination between skiers and non-skiers or various levels of skiing competency.

The level of significance did not reach .01 at slow speed primarily due to the fact that both groups of subjects appeared to be disinterested in the task at slow speed. The vigilance of the Skiers was better at medium and fast speeds than at slow speed. Mackworth (49) has found that performance decreases in vigilance tasks as the task continues, due to a lack of interest; while Welford (15) has found that decrements in performance may be due to drowsiness or similar lack of interest. Fitts and Posner (4) suggest that in tracking behavior of highly skilled performers, the efficiency will decrease as task duration increases. The close approximation of practice (6.0 rpm.) and slow speeds (6.5 rpm.) may also have caused the similarity of performance between the Skiers and Non-skiers at slow simulation speed. The resemblance of the task to actual skiing may have enabled the Skiers to out perform the Non-skiers. The skill was basically novel to the Non-skiers.

Some of the Skiers reported to the researcher that performance on the ski simulator was unlike the actual sport

of skiing in regard to body movement. The subjects, when operating the ski simulator, utilized primarily foot and lower leg movements; while the skier performing on the actual slope required more use of the arms and total body movements. On the other hand, the Skiers seemed to have more experience than the Non-skiers in the simultaneous movement of both feet in one direction on the ski simulator. This particular movement appeared to be novel to the Non-skiers. The Skiers also seemed to know the precise instant to turn the simulated skier prior to advancing through a gate in order to be better prepared for the oncoming gate. Poulton (11) stated the importance of pacing in tracking performance. The subject must continually make movements of a specific size, but the size of these movements varies constantly. If a subject makes a movement of the correct size at the wrong instant, it is as if he were to make an incorrect movement. The execution of the precise response at the correct instant is of the utmost importance in tracking skills. The Skiers, in contrast to the Non-skiers, appeared to be much more relaxed in their movements on the ski simulator, and their familiarity with the concept of pacing may have aided their performance.

The ski simulator when operating at fast speed (8.0 rpm.) proved to be the most difficult for both groups of subjects. There appears to be a resemblence between the sport of skiing and some aspects of performance on the ski simulator, as previously mentioned. However, the very rapid

movements of the feet on the pedals at fast speed may have been novel to even the Skiers. Similar movements are apparently used by skiers, but the speed at which these movements are performed on the ski simulator are much faster than in actual skiing, with the possible exception of slalom racing. Also, as noted by Poulton (11), high speed tracking task strategy is very difficult and a detrimental effect on performance may occur at a high speed. Craik (25,26) found that subjects could not make error corrections at a rate faster than two per second. At a fast speed of the ski simulator, once a gate was missed by a subject it appeared that the majority of subjects needed a few seconds to read-just to the course. The subjects experienced disturbed sensory feedback and additional gates were missed after the initial error during the period needed for readjustment, in many instances, at the fast (8.0 rpm.) speed.

The first portion of the Review of Related Literature was concerned with specificity/generality of motor performance. It was important to establish whether performance was task specific, that is, the type of foot-eye coordination necessary in the sport of downhill skiing may not be that which is needed to dribble a soccer ball or field a baseball. The majority of the literature concerning motor performance and motor learning supported task specificity (16,18,20,22,28,29,31,32,33,34,35,40,45,53,54,61,62, 63,64). Thus it should not be assumed that if an individual is a good skier, he would also perform well on the ski simu-

lator; or conversely, that a non-skier would perform poorly on the ski simulator. Even though the ski simulator task and the actual sport of skiing require the participant to possess foot-eye coordination in order to perform proficiently, the degree of coordination needed in the two tasks may be different. However, the fact that the Skiers out performed the Non-skiers on the ski simulator at all three speed levels did not indicate exclusively generality of performance; but rather it did show that positive transfer of coordination had occurred. Henry (15) indicated in his studies concerning transfer of coordination that transfer only occurs if the second skill is very similar, or almost identical, to the original skill. From the results of this study it may be concluded that the skills of skiing and ski simulator performance are very similar in nature. If soccer players, in which a different type of foot-eye coordination may be present, were tested on the ski simulator and exhibited similar performances to that of skiers, then it could be concluded that some generality of foot-eye coordination may be present.

Reliability Data

Product-moment correlation coefficients were calculated for slow, medium, and fast speeds of the ski simulator for Group I (Non-skiers) and Group II (Skiers). Two of the coefficients of the Non-skiers, .87 at medium speed and .90 at fast speed, were significant beyond the .01 level. The third coefficient, .14 at slow speed, was the

only correlation coefficient that was not significant. This low coefficient was due to a 1.75 decrease in mean error score between the original test and the retest on the ski simulator at slow speed. The improvement of the Non-skiers who were retested may have been due to several factors. First, some degree of learning may have taken place; secondly, there may have not been a long enough period of time between the original test and the retest; and thirdly, the small number of subjects (N=8) may have adversely affected the correlation coefficient. All three of the correlation coefficients for the Skiers were found to be statistically significant at or beyond the .05 level. Thus, these significant correlations indicate that if this study was repeated under similar conditions utilizing the same subjects, similar results would occur in at least 95 percent of the cases.

The standard deviation was larger than the mean at slow speed of the Skiers ($\bar{x}=1.87$, S.D.$=2.35$). This result may have been due to the fact that seven of those retested had error scores of three or less, while one subject had an error score of six. This phenomena is referred to as a positive skewness.

After examining the reliability coefficients in this investigation, 5 of the 6 meet the minimum .75 level suggested by McCloy and Young (6) as the minimum correlational level for retention of a test for the use of testing motor skills. Of the two other studies utilizing paced

contour tracking tasks, Straub (65) does not report any reliability coefficients while Whitley (66) reported moderately high learning reliability coefficients of .77.

Foot-eye coordination studies which utilized tasks other than paced contour tracking skills were completed by Fleishman (31) and Smith (17). Fleishman (31) reported reliabilities of 2 rudder control tasks as .70 for the single target task and .82 for the triple target task. Smith (17) utilized a tracing board in which the subjects traced a diagram using their feet. Two of the 10 correlations were significant in the foot-eye coordination test, but none met the .75 minimum correlation level as established by McCloy and Young (6) for retention of a test for use in testing physical skills. Roth (60), Crancer (27), and Rafaelsen (58), utilized simulated driving apparatus to test the effects of alcohol and marijuana on driving performance. None of these three investigators utilizing simulated driving apparatus reported reliabilities of the instrumentation.

Chapter 6

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS
FOR FURTHER RESEARCH

The final chapter consists of three segments:
summary, conclusions, and recommendations for further
research. A summarization of the study is given in the
first section of the chapter. The middle portion of the
chapter concerns conclusions that were drawn from the
results of the investigation. Suggestions regarding
further research in the area of foot-eye coordination and
the use of the ski simulator are listed in the final
section of the chapter.

Summary

Sixty male subjects between the ages of 17 and
25 years volunteered to participate in the investigation.
Their mean age was 20.69 years. Forty-nine of the parti-
cipants were enrolled at Ithaca College during the Spring
semester of 1973; while the remaining 11 subjects planned
to enter college in the Fall of 1973. These 60 subjects
were divided equally into 2 groups of 30 subjects each.
Group I, Non-skiers, consisted of 30 subjects who had no
experience in the sport of skiing prior to their testing
on the ski simulator. Group II, Skiers, consisted of 30

students who had skied for a period of at least 3 years
prior to their testing on the ski simulator.

The ski simulator was utilized to test foot-eye
coordination of college Skiers and college Non-skiers.
Each subject in both groups, the Non-skiers (N=30) and
the Skiers (N=30), was given one trial at each of the
three different speed levels (slow, medium, and fast) of
the ski simulator. Prior to the actual testing, each
subject was given a practice trial at a speed of six.
This speed approximated the first actual test speed
designated as slow. The test speeds used in the investi-
gation were as follows: slow, six and one-half; medium,
seven and one-quarter; and fast, eight. The researcher
recorded the number of gates missed by each subject on each
trial on the ski simulator, and this value was referred to
as the subject's error score.

Three sources of data were collected by the
researcher during the investigation: demographic, experi-
mental, and reliability. The demographic data were recorded
by each subject on a questionnaire which was developed by
the researcher. Each subject recorded his age, height,
weight, and information concerning his skiing experience.
The means and standard deviations of the demographic
variables for both groups, Non-skiers and Skiers, were
calculated by the use of a tally statistics program on the
Ithaca College computer. There were no statistically

significant differences (.05 level) between Group I and

Group II on the demographic variables of age, height, and weight.

The second source of data collected by the researcher was the experimental data. The experimental data were the actual test scores, or error scores, for each subject on the ski simulator. The means and standard deviations of these experimental data were also calculated on the Ithaca College Spectra 70/35 RCA computer. It was found that a statistically significant difference (.05 level) existed between the Non-skiers and Skiers when the ski simulator was operating at slow speed. A statistically significant difference beyond the .01 level was found between Group I and Group II when the ski simulator was operating at both medium and fast speeds. The Skiers outperformed the Non-skiers at all three speed levels.

Multiple discriminant function analysis was utilized to compare the two groups for overall foot-eye performance on the simulator. The Wilks' Lambda criterion was found to be significant beyond the .0001 level. Discriminant score weights were also calculated, and a .889 value was found at medium speed. This value contributed the most to the between groups variance. Therefore, it was concluded that the ski simulator was found to be the best predictor of foot-eye coordination between college skiers and college non-skiers when operating at medium speed. In addition to these findings, the Mahalanobis' D^2 statistic, a distance measure, also reached statistical significance

at the .001 level.

The final source of information collected by the researcher was the reliability data. Eight subjects were retested during the third week after their initial test on the ski simulator. They were tested in the identical manner as their initial testing procedure. Product moment correlation coefficients were computed to determine the reliability of the simulator. The reliability coefficients of the ski simulator for Skiers were found to be significant at all three speed levels. A .92 correlation coefficient was significant beyond the .01 level at slow speed; while coefficients of .79 (medium speed) and .83 (fast speed) were both significant at the .05 level. Of the 3 correlation coefficients found for Non-skiers, 2 values were significant at the .01 level; .87 at medium speed, and .90 at fast speed. Only a coefficient of .14 was not found to be statistically significant at the .05 level; and this was at slow speed for the Non-skiers.

Conclusions

The researcher has drawn two major conclusions from the results of the investigation. Due to the fact that the college Skiers significantly outperformed the college Non-skiers at all three speed levels of the ski simulator, within the limitations of the study, it can be concluded that male college skiers possess better foot-eye coordination than college non-skiers. The data did not support

the major null hypothesis which stated: There will be no significant difference in foot-eye coordination of college skiers and college non-skiers as measured by the ski simulator. It is important to note, as the review of the literature has indicated, that skills requiring foot-eye coordination may be highly task specific. Conclusions drawn from this study, therefore, may not be valid for subjects of different age levels than the subjects who participated in this investigation.

It can also be concluded, within the limitations of the study, that the ski simulator is very reliable in the measurement of foot-eye coordination. Five of the 6 correlation coefficients were above .79 and reached statistical significance (.05 level). Only 1 coefficient did not reach statistical significance at the .05 level, a .14 value at slow speed for the Non-skiing group.

Recommendations for Further Research

The major limitation of the investigation was the small sample size utilized for the study. Although the results indicated that college skiers possessed a greater amount of foot-eye coordination than college non-skiers, additional studies in this area of neuromuscular coordination utilizing larger sample sizes are needed to either support or refute the results of the present investigation. If similar studies support the findings of this investigation, the ski simulator may be of value in helping to

eliminate some of the ski injuries which occur each year. Beginning skiers who score poorly on this test of foot-eye coordination may be discouraged, or even prohibited, from skiing on the more difficult slopes before a designated period of time is spent on the beginner slope. A system such as this may keep the inexperienced skier from sustaining injuries to himself or other skiers on the slope.

Some recommendations for further research in the area of foot-eye coordination, and in the use of the ski simulator, are listed as follows:

1. Other studies comparing foot-eye coordination between skiers and non-skiers should be completed. These investigations should include: (a) subjects of varying age levels, (b) larger sample sizes utilizing random selection procedures with college age subjects, (c) female skiers and non-skiers. The results of the present study should be refuted or supported through further research.

2. The ski simulator may be used to measure the foot-eye coordination of athletes in different sports in which this factor is believed to be an important quality. The simulator could be used to test athletes participating in the same sport but at different positions to determine the importance of foot-eye coordination at each position.

3. The ski simulator could be utilized in studies testing the effects of physiological factors, e.g., alcohol, drugs, fatigue, stress on the performance of foot-eye coordination type skills.

4. An instrument such as the simulator could be utilized as a novel skill involving learning or factors affecting the learning of foot-eye coordination, e.g., spectator effect upon the learning of a foot-eye coordination skill.

5. A beneficial study may be to determine the improvement in performance on the ski simulator after the subject has been administered a course in skiing by a certified instructor.

6. The ski simulator may also be utilized as a training device in the acquisition of techniques used in skiing.

APPENDIX

APPENDIX

I. personal Data

Age:_____

Height:_____

Weight:_____

What is your major at Ithaca College? _____

II. Ski Experience Data

Have you ever utilized the ski simulator? _____

How many years have you skied prior to
the 1972-73 school year? _____

How many times (average) did you ski during
the previous years per year? _____

How many times did you ski during the past
Winter? _____

What slope do you primarily ski on?
(beginner-intermediate-expert) _____

How many ski lessons have you taken from
a certified instructor? _____

Have you ever had an injury serious enough
to consult a physician, due to skiing? _____

What type of injury? _____

What was your experience skiing, in years,
at the time of injury? _____

What slope were you skiing on at the time
of injury? _____

III. Experimental Data

Error Scores:

Slow Speed:_____Medium Speed:_____Fast Speed:_____

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