

Training Anticipation for Advanced and Intermediate
Tennis Players: A Behavioural Approach

by

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ABSTRACT

The purpose of this study was to: (i) examine the ability of advanced and intermediate tennis players to accurately predict the type, depth, and width of tennis serves, and (ii) to examine the trainability of serve type, depth, and width identification by intermediate tennis players. In Experiment I subjects (N=38) viewed tennis serves, on a video and were asked to identify the type of serve, the depth of serve, and the width of serve. Ninety serves were presented at two different speeds (regular and slow motion) for a total of 180 video presentations. Performance of the advanced and intermediate tennis players, with respect to the three measures previously described were analysed and compared. There was a significant difference ($p < .05$) in the level of prediction accuracy between the groups for both speeds of presentation. Post hoc analysis revealed however that no significant differences in prediction performance existed between the groups for serve depth and serve width at slow speed. Further analysis of prediction performance revealed significant correlations for both advanced and intermediate players at slow and regular speed. The results of the study suggest that differences in serve prediction performance between advanced and intermediate players may result from differing information detection, amount of information being processed, and processing speed. Experiment II concerned the assessment of the impact of a video training protocol on serve reception and return skill. A multiple baseline design

across six subjects was implemented with pre and post intervention scores for serve return performance on court being recorded. Intervention consisted of series of video presentations of serves, all of which were occluded on contact. Subjects were asked to predict the type, depth and width of serve. A modified changing criterion design was implemented during intervention, that is, on reaching a certain predetermined level of performance accuracy, subjects progressed to a faster video play speed. On court results would suggest that performance did improve as a result of the video presentations.

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DEDICATION

To

Poo

CHAPTER 1

Introduction

One of the characteristics of the environment of open skill sport is the variety of sources of information which change rapidly and repeatedly. The athlete must quickly and constantly select the relevant visual cues in addition to discarding or ignoring the irrelevant (Bard and Fleury, 1976). This selection is by no means a random process but rather one which, with some degree of precision beyond that of the level of chance, predicts the intentions or actions of one's opponent (Buckolz, Prapavasis, and Fairs, 1988). Prediction of future intentions is obviously fraught with difficulties, but it is clear that certain athletes are much more skilled at this process than others.

Tennis is an example of an open-skill sport where perceptual and information-processing skills are important. This skill becomes more critical at advanced levels of play where rapid decision-making is required. In fact, the size of the court and the speed of the shot often means that unless the flight path of the shot is anticipated early, efforts to reach the ball and play an effective return will be in vain (Day, 1980). This is particularly true of serve reception where tennis serves may reach speeds of over 220 kilometers per hour. In such circumstances athletes are in a time-pressured situation and are obliged to predict the intentions of their opponents. However, as pointed out by Buckolz, Prapavasis, and Fairs (1988) this can be a

risky venture, particularly because of the negative consequences that result when predictions are incorrect.

Shank and Haywood (1987) have suggested that information-processing theory predicts that eye movements reflect the processing of information. They contend that eye movements reflect the performers fixation on specific cues and that these movements are organized into visual search patterns which vary from expert to novice. Other researchers (Buckolz, Prapavesis, and Fairs 1988) however, have suggested that while cue fixation is important, information processing efficiency is also important. Such an approach to the study of expert-novice differences suggests that anticipation is based on prediction, especially in a situation such as serve reception. In such a situation it is important for the performer to seek out relevant cues in advance of the action and to efficiently process the information that these cues contain.

Early or advance cues may be derived from two major sources: (i) situational, which includes aspects such as climate conditions, playing conditions, and the strengths and weaknesses of the opponent, and (ii) movement cues, which include the stance, racquet action, and visual focus of one's opponent. As pointed out by Buckolz, Prapavesis, and Fairs (1988), the time pressured individual can benefit from advance cues because they encourage prediction or anticipation which in turn offsets the time constraints of the task. It is apparent that advanced tennis players predict at a better than chance level, thereby providing indirect evidence that advance cues do possess some measure of predictive validity. However, what is unclear is how advanced players, in comparison to intermediate

players, are able to use advance cues effectively. There seem to be three possible explanations (Abernethy, 1992). First, advanced and intermediate players could be using different advance cues. Second, advanced and intermediate players could have equal knowledge of advance cues, but differ in their ability to quickly and efficiently process them. Third, a combination of the first two hypotheses whereby advanced players use some different cues in addition to processing more effective information-processing skills.

Another area of concern is ecological validity, that is, research dealing with advance cue utilization has not been studied in the context in which it is actually used. Studies in the area have generally involved simulated displays and pencil-and-paper or verbal responses. Mestre and Pailhous (1992) have expressed concern over the use of simplified motor responses and the possible artificial uncoupling it may create between perception and action. Similarly, von Hofsten (1987) has suggested that perception should be studied in the context for which it evolved. There is clearly a need for more field related research.

Statement of The Problem

The purpose of this study was three-fold:

1. To examine anticipation in sport in terms of inferred information-processing speed rather than the traditional method of recording eye movements, scanpaths and visual search strategies.

2. To assess the effect of a video presentation on information-processing speed and performance in a simulated environment. More specifically, the purpose was to determine rates of prediction accuracy with increasing video play speed.

3. To assess the effect of a video presentation on information-processing speed and performance in a sporting environment by means of a behavioural approach. More specifically, the purpose of the study was to investigate the trainability of on-court serve return performance through a series of videotape presentations.

CHAPTER II

Review of Literature

The Development of Information-Processing Theory

Information-processing is not a single theory, but rather a framework characterizing a large number of concepts (Miller, 1983). These various concepts attempt to explain the flow of information through the cognitive system, beginning with an input, and ending with some form of output. Between input and output, information is attended to, transformed, compared, assigned, and used to formulate a response (Miller, 1983). As a result it has often been suggested that these mental processes are analogous to the workings of a computer as both humans and computers manipulate symbols and transform input into output.

It should also be noted that the development of information-processing theory has, for some researchers (Gordon, 1989), come to mirror the development of a neurological approach to psychology. With the development of information-processing thought, it has been suggested by Gordon (1989) that psychological hypotheses can be replaced by models based on known neural mechanisms. There are a number of good reasons why a significant number of perceptionists have favoured this shift (Gordon, 1989). In the first place it is assumed that neural mechanisms underlie much behaviour. Second, there are those that feel that psychological knowledge is more secure when it can be linked to known physical structures. Third, it has been suggested that some researchers find it easier and more

satisfying to think in terms of neural mechanisms rather than in more abstract psychological terms.

Information-processing models in psychology are not new. For example, Freud's psychoanalytic theory of motivation and personality is explicitly a processing model. According to Miller (1974) this model suggests that energy undergoes numerous investments and shifts as a function of development and experience. There have been early processing theories in perception as well. The microgenetic analysis stressed by Werner is a prime example. Werner (1935) argued that perception should be characterized as a temporal growth process, that is, a growth in clarity.

Nevertheless, Haber (1974) argued that there is no one central figure who may be thought of as the founder of information-processing theory. Rather, Haber suggested that there are two major antecedents, neither of which are directly linked to psychology. These are the communication theory of Shannon and Wiener (1949) and the arrival of digital computers.

The communication theory of Shannon and Wiener (1949) was originally applied to telephone switchboard systems, although its general application has been far greater. They provided a model of communication in terms of channels over which messages are transmitted. The importance to perceptual theorizing of this model was the ease with which it could be applied to human perceptual systems, which may be viewed as communication channels. A direct result of this work was a new information-processing language, with psychologists beginning to talk about "limited-capacity channels," "serial and parallel processes," and "information coding."

The second antecedent was the explosive growth in the use of digital computers which began shortly after World War II. During that war, psychologists had moved out of the laboratory because of the need to improve the human operation of wartime equipment and weapons. It was not the use per se, but the awareness by psychologists of the existence and capabilities of computers that influenced their thinking. Theorists began to speculate on similarities between computer operations and human behaviour, and even to computer simulate such tasks as perceptual learning, recognition, problem-solving, thinking, and gaming. Psychologists borrowed the language of computers; channels, gating, serial and parallel processing, storage buffers and so on, whilst also developing perceptual theory along the lines of computer programs; flow charts, subroutines, processors, buffers, memory, and so forth.

Haber (1969) pointed out that information-processing analysis assumes that "the total time from stimulus onset to the occurrence of a perceptual response can be divided into intervals, each characterized by a different operation" (p. 2). This approach makes explicit that perception, as an experience or awareness by the perceiver of having been stimulated, cannot be immediate. Rather it is an end product of a number of separate operations, stages, or processes, each of which occur in sequence (or parallel sequences), and takes time to complete. Haber (1974) therefore suggested that immediacy of perception is perhaps a 'dead horse,' although it has had an illustrious history in theories of perception.

A second implication of the information-processing approach is a recognition of how processing is limited by channels through which

information flows. One of the earliest proponents of this concept was Welford (1952) who proposed that humans have a limited capacity to process information. Although a number of theorists have justifiably proposed that such a theory, in a strict sense, is incorrect, this notion has led to the development of a number of more complex models all of which have as their basis the concept of a "channel" (Legge and Barber, 1976). This approach affords us a better perspective with which to look for the stages at which the recoding of information takes place and to examine the determinants of loss or change in content. The points in time where recoding takes place are central to information-processing theories and analysis, and it is here that most interest, excitement and controversy has arisen.

Information-processing theory has been used extensively in sport, particularly with regard to decision-making. Bakker, Whiting, and van der Brug (1990) have suggested that reactions will become faster because events in the environment show specific relations which are discovered during the learning environment. They pointed out that the discovery of "redundancy" enables one to predict certain events on the basis of the occurrence of others, resulting in a decrease in time needed to react to them. A real-life example is offered by Mohammed Ali (1975) who in a fight had struggled against his opponents left cross "I had his movements so catalogued and timed that I knew the meaning of the slight twitch that would involuntarily appear in his throat when he was about to smash the bomb. Then I would cut over his blow(pp. 321)." Examples of such anticipation are found in numerous sport situations.

Visual Search Activity and Information-Processing

In the human being, sampling of the optical array involves four differing procedures. A *fixation* is a brief period of time during which the eye is stationary and focused on a single part of a scene. Such fixations last between 200 and 500 milliseconds, and one to five degrees of visual information is processed. Fixations are separated by quick movements, or *saccades*, during which the eye's focus is changed to a new section of the picture. According to Yarbus (1967), saccades rarely move the eye more than 15 degrees of visual angle and are such quick movements that they occupy only about five percent of the total time spent scanning a picture. Saccades are so quick that they are unnoticed by the perceiver. During the movement, visual information is 'blurred' across the retina, and mechanisms in the visual system act to suppress the blurred information taken in during a saccade (Sproehr and Lehmkuhle 1982). Once an object is fixated, *pursuit* movements keep it in foveal vision as the observer moves. If the distance of an object changes, *convergence* movements keep it fixated by the fovea's of both eyes. As an object comes closer, convergence movements turn the directions of gaze of both eyes toward the nose. If an object comes within a few inches of the face, further convergence is impossible and double vision occurs. Whereas saccades are sudden, intermittent changes of eye position, both pursuit and convergence are smooth, continuous eye movements.

In a great many sports, performers are often concerned with knowing whether or not they will contact something, how soon it will happen, and how violent it will be. A brand of physics, known as

ecological optics has been developed (Gibson, 1966) which seeks to describe surfaces and events in ways that are directly relevant. According to Carello and Turvey (1991) the premise of ecological optics is that the substances of our textured environment reflect light in a way that is peculiar to those substances and surfaces. Should the point of observation move, a flowing array known as an optic flow, will be produced. For example, if a tennis ball is traveling toward you, its movement generates an expanding optical angle with its rate of expansion depending on the velocity of the ball. At the same time, the inverse of this rate of expansion relates to how soon the ball will hit you. For this reason, it is called the time-to-contact variable or tau (Lee, 1980).

Goulet, Bard, and Fleury (1989) suggest that eye-movement recording can reveal valuable information: (a) It allows testing in ecological situations. (b) It allows the selection and identification of the most informative cues, from which a filtering capacity can be inferred. (c) It allows the quantification of the amount of information selected (number of fixations per unit of time). (d) It allows the establishment of a visual search strategy (scanpath), revealing the dynamic priority of the subject.

Vurpillot (1972) stated that visual search, revealed by the sequence of eye fixations, shows which information people select and consequently which guiding information they consider most important for their decisions. Thus, according to Shank and Haywood (1987), information theory predicts that eye movements reflect the processing of information. This suggestion was first examined by Gould and Schaffer (1965). They reported that experience played a

major role in visual search patterns and in the corresponding outcomes or responses. They found that subjects having participated extensively in tachistoscopic experiments had 50 percent fewer fixations than subjects without such experience. The underlying assumption made in this study and in similar studies (Mourand and Rockwell, 1972), is that there a direct relationship between eye fixation and information-processing; that is, we process what we look at. This premise has been the basis on which a series of studies examining perception in sport have been instituted.

Bard and Fleury (1976) investigated the visual search patterns of advanced and novice players solving basketball problems. They reported that not only was the search pattern specific to the type of task presented to the subject, but that the subject selected only those elements which they believed to be pertinent to the solution of the problem. Bard and Fleury also reported that the number of fixations, for experts was statistically less than for novices.

In a study of the visual search patterns of gymnastic judges, Bard, Fleury, Carriere, and Halle (1980) examined the number and location of ocular fixations during the evaluation of a gymnast's performance, and the number of errors made by the judges. They reported that expert judges showed fewer fixations than novice judges, that the location of fixations differed from expert to novice, and that novice judges detected only half of the gymnast's errors observed by the advanced.

In the continuing series of these studies, Goulet, Bard, and Fleury (1989) examined the visual patterns of expert and novice tennis players in preparing to return a tennis serve. They reported

that experts identified more serves correctly than novices, took better advantage of preflight cues when asked to anticipate the type of serve delivered, and focused on different cues from those utilized by novices.

Abernethy (1991) has pointed out that the study of visual search is characterized by substantial limitations and assumptions. In particular movement recording methods only reveal information related to central or foveal vision. Consequently important information picked up by means of peripheral vision is not detected by visual search equipment. Furthermore, there is a clear distinction between looking and seeing. Stager and Angus (1978) have demonstrated that target objects can be fixated without being detected and Shulman, Remington, and McLean (1979) revealed that attention can be redirected without making eye movements. Finally, Abernethy (1991) has suggested that there are questions concerning trial-to-trial variability relating to the use of the visual detection equipment. It may well be that in certain instances the visual recording equipment may be obtrusive enough to force subjects to alter their normal visual search strategy.

In a series of studies conducted by Abernethy and colleagues, the performance of expert and novice players was further examined. However, unlike Bard, Fleury, and Goulet, Abernethy focused on overt decision-making based on advance cue utilization, rather than on eye movements and scanpaths. In the first of a series of studies, based on preliminary work (Abernethy, 1981), Abernethy and Russell (1984) examined the importance of cue sources to decision-making in cricket batting. They conducted two experiments in which

the time available to view the visual display, before reaching response selection, was either under subject control, or under experimental control. In the first experiment, in which ball flight information was available, expert batsmen produced more accurate stroke selection than novice batsmen. In the second experiment, in which ball flight was occluded and the viewing time was held constant for all subjects, there was a trend for greater extraction of advance information by the expert batsmen.

In a second study, Abernethy and Russell (1987a) compared the temporal and spatial characteristics of the anticipatory cues used by expert and novice racquet sport players. The perceptual display used in badminton was simulated using film, and display characteristics were manipulated by varying the duration of the stroke sequence that was available. The subject's task was to predict the landing position of the stroke they were viewing. They reported that expert players were able to predict more accurately on the basis of information selected from earlier display cues than could novices.

In a follow up study, Abernethy and Russell (1987b) examined the relationship between selective information pick-up and visual search activity as it relates to skilled performance in squash. Expert players were again found to be able to pick up earlier advance information than novices. However, this difference in information extraction was not matched by differences in visual search characteristics with the location, duration, and sequence of the novices' fixations on the film display being indistinguishable from those of expert players. Abernethy and Russell therefore concluded, with regard to the sports they had examined, that the major source

of expert-related differences in sport perception is not the visual search strategy per se but rather the use to which the received information is subsequently put.

Buckolz, Prapavesis, and Fairs (1988) investigated advance cues and their use in predicting tennis passing shots. They suggested that there were two possible explanations for how advanced players use early cues more effectively than intermediate players. First, intermediate players may be unaware of what constitutes reliable cues. If this is the case, players should report using different cues from those identified by the advanced players. Second, advanced and intermediate players may have equal theoretical knowledge of which telegraphic cues are relevant; however, they may differ in their ability to detect these cues under normal speed conditions. In their study they reported that advanced players correctly predicted more passing shots than intermediate players. However, they reported that both the advanced and intermediate players tended to report using the same cues. Buckolz, Prapavesis, and Fairs suggested that while intermediate players knew which cues to look for, they were less efficient than advanced players in detecting their presence under normal speed conditions. However, when the prediction film was played at a much slower speed, the difference in accuracy prediction between the two groups decreased markedly. This suggested that the difference in prediction accuracy between the groups resulted from a detection efficiency in favour of the advanced group.

In a recent review of the area, Abernethy (1992) pointed out that in his research series on perceptual expertise in racquet sports, subjects viewed a simulated display of an opponent's action. During

the viewing they were required to respond, not by actually moving and hitting a return stroke, but simply by either marking on paper the estimated landing position of the opponent's stroke or by verbally categorizing, in very general terms, the direction and force of the opponent's stroke. The value of using a simplified motor response was that it allowed Abernethy to focus directly on perceptual differences between expert and novice performers, without performance measures being confounded by movement production skills. However, Mestre and Pailhous (1992) expressed concern over the use of simplified motor responses and the possible uncoupling it may create between the normal functional links of perception and action. Similarly, von Hofsten (1987) suggested that perception should be studied in the context of the actions for which it evolved. The views represent an ecological validity perspective in which the quest is ultimately to determine how perception and action interact.

The ecological validity issue emphasizes “that the artificial situation created for an experiment may differ from the everyday world in crucial ways..... When this is so, the results may be irrelevant to the phenomena that one would really like to explain” (Cafferata, 1989, p. 329). In other words, if theories developed in the laboratory are to be relevant outside it, the processes studied in the laboratory must have ecological validity.

Runeson (1977) has suggested that there are potential problems in examining perception under conditions where the action required is different from that needed to perform the intact skill of interest. There is also a danger in under-estimating the perceptual

capabilities of subjects under such conditions. Mestre and Pailhous (1992) support this position. They point out that in studies involving occlusion, subjects “only” have to predict the force and direction of a stroke (and not to return the ball) has to be kept in mind. Similarly, Turvey and Carello (1986) have observed that a full understanding of expertise in sports requires a perception and action cycle approach.

Mestre and Pailhous (1992) also suggested that an opponent’s action and ball flight must be studied together since visual and peripheral information during ball flight appears to be much more important in the real field. They hypothesized that an opponent’s actions were important in judging the nature of the stroke but that ball flight information was required to precisely judge ball depth and time of arrival. This research has received empirical support from Savelsbergh and Bootsma (1994). It was reported that players in table tennis demonstrated that the execution of a forehand drive is guided by a very fine time-to-contact perception-action coupling. This guidance is so effective that highly skilled players demonstrated minimal fluctuation (2-5 ms) in timing accuracy across a number of forehand shots. It had previously been suggested by Tyldesley and Whiting (1975) that such timing accuracy could be due to a players’ ability to produce low variability drives. Furthermore, it was suggested that if players could consistently produce the same movement, then the timing problem becomes one of accurately initiating the drive. This gave rise to the assumption that an accurate moment of initiation would lead to an accurate moment of contact. However, Savelsbergh and Bootsma reported that the temporal

accuracy at the moment of initiation, as well as the variability of movement times being produced, were of such magnitude that such a strategy was not viable. Nevertheless, Savelsbergh and Bootsma reported that the amount of acceleration produced during the drive suggested that players were able to adapt their drives. If the drive was initiated somewhat later than average, the player produced somewhat more acceleration, and vice versa. Thus, Savelsbergh and Bootsma concluded that it is a finely tuned perception-action coupling mechanism that is responsible for accurate contact. This position has received some support from Abernethy (1991) who acknowledged that although advanced cues are important the ability to use flight cues and correct responses accordingly plays an important part in shot performance.

In obtaining empirical data on the differences in attunement to available sources of perceptual information between advanced and intermediate players, two research strategies are possible (Abernethy, 1992). One approach places ecological validity at a premium and proceeds by making natural observations of the skill of interest with a minimum of experimenter imposed constraint. Perception and action are retained within their normal relationship although the chances of unearthing important control variables are somewhat lessened. The alternative research strategy is to initially constrain and simplify the task of interest in some way so as to conduct a systematic search for information sources. This is the strategy which has been employed almost without exception in the area. However, this approach is clearly lacking in ecological validity. The fact that Abernethy's subjects "only" had to predict the force and

direction of a stroke, and not to return the ball, clearly reduces its applicability to the "real" situation.

Theoretical Mechanisms Underlying Performance Improvement Due to Training

What is Being Trained -- Information Processing Speed

It has been suggested by Salthouse (1985) that in the context of the information-processing model, both the amount of information that can be handled at one time and the quality of information-processing, are accounted for by one resource: information-processing speed.

Carlton (1987) has pointed out that the temporal delay between picking up visual information and using this information to trigger or guide our movement is critical in regard to sport performance. Studies of this factor have employed reaction time paradigms which date back to the work of Donders (Koster, 1969). However, Carlton (1992) has noted that there have been few systematic attempts to determine the factors that contribute to information-processing and movement. One possibility is that ability-related differences in the amount of processing resources give rise to differences in information-processing speed. However, there is a problem with this interpretation since ability-related differences in processing resources which is the mechanism used to explain differences in processing speed, is dependent on ability-related differences in processing speed (Hale, Fry, and Jessie, 1993). Nevertheless, a number of other speculations can be made.

McCloskey, (1981) has suggested that kinesthetic inputs as well as information about motor commands as an "efference copy" provide information about movement. By knowing the time when visual information will be available, and by knowing the probable response and response adjustments that may have to be made, visual information may be processed and used more rapidly. Another factor which could account for the variety of processing time estimates between individuals is the size of any error or uncertainty which may need to be corrected or accounted for (Carlton, 1992). A high degree or magnitude of errors may require a fundamental reorganization of the movement to accomplish the task goal, whereas small adjustments may only require lower level neural processes (Prablanc and Pelisson, 1990).

Various researchers have hypothesized that response latencies may decrease because of increases in the efficiency of information-processing, that is, the elimination of processing steps (Myerson, Hale, Wagstaff, Poon, & Smith, 1990; Newell & Rosenbloom, 1981). It may therefore be argued that expert and novice performers are performing basic information-processing tasks using the same sequence of component processes. Differences between the two groups may therefore result from the time and number of processing steps taken by novices.

It has been similarly reported by Hale, Fry, and Jessie (1993) that although children's latencies are more variable than those of adults when both are performing the same task, children's latencies are no more variable than those of adults when both groups are performing novel tasks that require an equal amount of time by both

groups. It is therefore possible that ability-related differences in variability reflect qualitative differences in the information processing of advanced and intermediate players; that is, the strategies used by intermediate players or the implementations of these strategies might be more variable than the strategies and implementations of advanced players.

Another explanation for the differences in processing information speed between advanced and intermediate players may lie with the development of automaticity. The concept of automaticity implies that skills may be performed without apparent conscious attention.

The contemporary view of attention is as a series of resource pools (Abernethy, 1993), each with their own unique capacities and resource-performance relationships. It is suggested (Fodor, 1983) that within such a theory of attention, capacity is distributed throughout the nervous system in specific, special-purpose subsystems and is not centralised. An example of such a subsystem is the autonomous visual mechanisms for the pickup of time to contact information (McLeod, McLaughlin, & Nimmo-Smith, 1985). However, given the enormous amount of information which bombards the performer every second it becomes essential that only the most relevant information actually gets selected and processed (Abernethy, 1993). In sport situations a number of factors will influence the efficiency of this selective attention process. These factors include the total amount of information on display, the amount of irrelevant information, the time required to pick up and process the relevant information, and the ability of the performer

(Jones, 1972). The older, formal filter theories of selective-attention still tend to dominate the selective attention literature (Abernethy, 1993) although alternative theories have been developed. The attenuation model of selective attention (Triesman, 1969) proposed a series of tests, with irrelevant information being progressively attenuated at each of these levels of analysis. The pertinence-based model of attention (Norman, 1976) assumes that short-term memory is the method for selectivity. Within this model signal pertinence, derived largely from the performer's past experiences and contextual knowledge of similar situations, is assumed to be the foundation on which the discrimination between those signals for further processing, and those to be ignored is based (Abernethy 1993).

Logan (1985) has pointed out that automaticity is an important component of skill in that performance of a skill consists of knowledge and procedures that can be carried out automatically. Furthermore, Magill (1993) has suggested that not only skill but automaticity can be acquired through practice and that automaticity should not be thought of as a dichotomous category but rather as a continuum.

What is Being Trained-- Transfer

According to Magill (1994, p. 71) transfer "is generally defined as the influence of having previously practiced a skill or skills on the learning of a new skill or on performing a skill in a new context." This influence, which may be positive, negative, or neutral, requires that, given the right conditions, what is learned in one context can be carried over to another context (Adams, 1987). Positive transfer

occurs when experience with a previous skill aids or facilitates in the learning of a new skill; negative transfers occurs when experience with a previous skill hinders or interferes with the learning of a new skill; zero transfer occurs when experience with a previous skill has no effect or influence on the learning of a new skill. Thus, one of the more important conditions which affects transfer is similarity between tasks. In fact, it has been suggested (Singer,1980) that the greatest amount of transfer will result from a greater resemblance between task elements and their respective stimuli and responses. Examples of positive transfer situations are racquetball-tennis, and ice hockey-ringette.

Examples of negative transfer are often harder to detect and often specific to particular components of skills. For example there is generally a positive transfer between tennis and badminton. However, the learning of the tennis forehand before the badminton forehand often results in negative transfer and vice versa. (The badminton forehand requires a wrist snap whereas the tennis forehand requires a firm wrist).

Theories of transfer may help explain findings with respect to changes in performance on court. However, the mechanism of transfer is not well understood. A number of hypotheses have been developed in an attempt to explain why transfer occurs. The more traditional view agrees that transfer is due to the similarity of components between two skills or two performance situations (Magill, 1994). This position can be traced to Thorndike (1914) and his theory of identical elements. Thorndike considered identical elements to be mental processes that shared the same brain cell

action as the corresponding physical action. This view was modified by Osgood (1949) who developed the theory of a "transfer surface" which provided a means for determining what type and amount of transfer to expect. As with Thorndike, Osgood proposed that the amount and direction of transfer is directly related to the similarity between the stimulus and response aspects of two tasks. Osgood suggested specifically that when both stimuli and response are similar, positive transfer will occur between the tasks. In other words, maximum positive transfer is predicted when the stimulus and response characteristics are both identical. On the other hand, negative transfer is predicted when the stimuli for the two tasks are identical but the two responses are completely different from each other.

A second hypothesis, the transfer appropriate-processing hypothesis (Bransford, Franks, Morris, and Stein (1979) focuses on the similarity of cognitive processing characteristics required by the two skills or two performance situations, rather than on the similarity of the physical components of a skill or the context characteristics of the two performance situations (Magill, 1994). This view is supported by Kolers and Roediger (1984) who provided a framework for accounting for significant aspects of cognitive processes in terms of skill in manipulating symbols. Within this framework they argue that the means of acquiring information form part of its representation in the mind, and that recognition varies with the similarity of procedures in acquisition and test, and that transfer between tasks varies with the degree of correspondence of underlying procedures.

In the context of the present research, the transfer appropriate-processing hypothesis implies that the nature of training and target tasks are less important than whether performance on the real task and that on the video require the same cognitive processes. Therefore, if it is the case that those processes required in making an on court decision are the same as those required on the training task, video training should be successful. Starkes and Lindley (1994) have suggested that if we understood what it is that transfers and how information transfers, designing a task simulation would be easy.

Finally, Singer (1980) identified two types of transfer; between activities or lateral transfer, and within activities or vertical transfer. Lateral transfer refers to influences of learning from one task to another, an example being tennis and badminton. Vertical transfer refers to influence of prerequisites on higher learning within the same task, an example being video practice prior to real practice.

It should be noted that the total transfer effect is dependent on a number of variables. These include the amount of practice, the schedule of practice, the individual's motivation to transfer skill or knowledge gained in one situation to another, and the intent of transfer.

The Training for and Development of Anticipation

One area that has come under close scrutiny is the training of anticipation and decision-making. This is partly the result of the increased use of video recording of games and game situations. As pointed out by Starkes and Lindley (1994) this type of training has several advantages. In regard to tennis, for example, court time is

not needed, the coach need not be present, and learning is self-paced. Furthermore, video tape training can be used with injured players, in conjunction with on court practices, and during the off season. This process of simulation is of course dependent on the ability of the athlete to transfer their video training to the actual game situation.

The use of simulation is widespread through out sport and includes such devices and practice aids as video golf, pitching machines in baseball, and tackling dummies in rugby. With such widespread and common use one might assume that such development is based on logical, empirical data. However, as pointed out by Chamberlin and Lee (1993) this is far from the case. The majority of the research on simulation has involved pilot training rather than sport.

Despite the lack of empirical data, a number of principles have been developed from pilot training, the most important being fidelity. The term fidelity refers to the extent to which simulation mimics the real-world task. Receiving an actual tennis serve would be very high in fidelity whereas practicing by using a serving machine or a video tape has decreasing levels of fidelity. Therefore, within industry, attempts have been made to develop simulators that are high in fidelity in the belief that this will increase the transfer of learning.

As to what is being learned it was initially thought that simulation developed declarative knowledge ("what to do" knowledge), primarily through neuromuscular coordination. However, according to Alessi (1988) researchers have begun to pay more attention to procedural knowledge. Alessi has suggested that

research done on simulation and fidelity has indicated that increasing the similarity between the practice and test environment enhances the transfer of procedural knowledge.

It has been suggested by Thomas and Thomas (1994) that a certain amount of declarative knowledge is needed prior to acquiring procedural knowledge, and that declarative knowledge is clearly important in the development of expertise. However, since high levels of declarative knowledge are often found in novices, this does not seem to be the limiting factor in the development of expertise. They pointed out however, that it is in the area of procedural knowledge that the greatest differences between experts and novices are to be found, but that the precise nature of procedural knowledge development is still a mystery. Nonetheless, it is thought that direct instruction and inference through play and observation are important developmental factors.

Simulation training has been used in major sport. Brockman (1991) reported that the Milwaukee Brewers baseball team used a sophisticated electronic imaging system during the 1990 season to help train pitchers. Training consisted of analyzing the speed, curve, and position of the ball on a simulated strike zone which was displayed by a floor mounted video projector.

Before commencing on a training program it is important to recognize precisely what is being trained. In the early part of this century it was thought that anticipation was dependent on perceptual and decision-making abilities and that these in turn were related to superior visual acuity, depth perception, and peripheral vision on the part of the elite athlete (Starkes & Lindley, 1994). In

one early study Bannister and Blackburn (1931) reported that the interpupillary distance of rugby players was greater than that of non players and concluded that the more advantageous angle of visual convergence of the players promoted superior depth perception, which enhanced their athletic ability. Similar findings have been reported by Olsen (1956), and Pierson (1956). However, although emphasis was initially put on these abilities, later work has demonstrated that performance by elite athletes is rarely due to superior visual talents. Martin (1970), as cited by Starkes and Lindley, (1994) found poorer-than-normal static visual acuity in 22% of the hundreds of national and professional athletes that he tested. Similar findings have been reported by Cockerill (1981), and Starkes and Deakin (1984). These results would suggest, that after 75 years of research, there are few conclusive results which link visual abilities with athletic performance.

Nevertheless, according to Starkes and Lindley (1994), we do know some things about elite athletes. They suggested that part of the reason why elite athletes excel is that they have stored in memory a large amount of declarative knowledge in regard to their particular sport and game structure. Furthermore, they would also seem to possess large amounts of procedural knowledge with regard to how and when to do certain movements or institute specific plays. In addition, they have also suggested that elite athletes seem to be particularly apt at accessing and retrieving this information.

The notion that video technology or simulation may be used as a means of developing or advancing athletes to greater levels of expertise is not a new idea. Haskins (1965) developed a perceptual

training device (training film) and investigated its effectiveness in shortening the time necessary to recognize the direction of a tennis serve. Eleven recreational tennis players participated in the study. Each player watched a slow motion film which was stopped before, at, and after contact. Each subject was then asked to select one of five buttons each of which represented specific ball flight directions. Haskins reported that the training film appeared to be beneficial in shortening the time necessary to perceive accurately the direction of a tennis serve. Furthermore, these benefits could be enjoyed by all players regardless of level. Londeree (1967) examined play-recognition times after training with motion pictures and flash cards in the game of football. Twenty-eight high school students were selected into one of two groups, dependent on their IQ level. Each subject was shown three segments of film. Each segment of film contained an actual football play. Each football segment was frozen at a certain point and each subject was asked to orally provide the correct defensive response. This process was then repeated with flash cards containing diagrammed plays replacing the film segments. Londeree reported that motion picture training resulted in shorter play recognition times than flash card training for defensive ends in football. He also reported that there was no relationship between IQ and performance. Thiffault (1974), cited by Starkes and Lindley, (1994) were trained to make fast offensive decisions to shoot, pass, or skate the puck, following brief exposure to slides showing game situations. It was reported that following training, vocal reaction decisions were made faster. It was further reported that this improvement carried over on to the ice. However, Starkes

and Lindley, (1994) questioned the ecological validity of the transfer task and queried as to whether training occurred which would actually facilitate performance in a real game. Finally, Burroughs (1984) examined the effectiveness of visual-simulation-training film approaches to enhancing the visual pitch recognition and pitch location skills of collegiate baseball players. Reports of the use of film to help improve batters' skills at the plate have appeared from time to time in the literature (Breen, 1967; Hubbard and Seng, 1954; Race, 1961; Reiff, 1971). It was reported by Burroughs that both slow motion and real time visual simulation training significantly improved batters visual location skills.

Starkes and Lindley (1994) reported on an earlier unpublished study by Lindley (1987) which examined the effectiveness, for basketball players, of perceptual training using slides and video tape. It was reported that pre to posttest slide and video results revealed a marked decrease in the time to make accurate decisions for groups trained on their respective test stimuli. However, it was also reported that although speed had changed there was no corresponding increase in accuracy of decisions. In addition it was revealed that performance improvement with regard to speed of decision-making did not carry over onto the basketball court. It was suggested that a possible reason for this was the shortness of the training period (three 1/2 hour periods over four days).

In a follow up study Starkes and Lindley, (1991) examined the video training of offensive decision-making in basketball. The video sequences were from a variety of university basketball games which were filmed from above half court. Tapes were viewed at real time

on a 20-inch television. In addition to video pre and post tests, on court tests were also administered. This consisted of subjects watching players playing on court who during a particular play "froze". Subjects were seated and given a score card on which to record their decisions with regard to what the "frozen" player would do. The intertrial interval was one minute. The authors reported that although the trained group produced significantly reduced decision-making time in comparison to the control group, there was no comparable increase in the accuracy of their decisions. This would suggest that structured video training can be an important addition to on court or real training. Starkes and Lindley further suggest that video training may be more beneficial with regard to decreasing decision-making time rather than decision-making accuracy. However, it should be noted that training sessions were again brief in nature (six sessions) and may not have been long enough to bring about changes in decision-making accuracy. Nevertheless, the results of these studies suggests that simulation may be a possible method of training anticipation.

A Technique For Anticipation Development: Behaviour Modification and The Changing Criterion Design

The development of behaviour modification grew from a dissatisfaction with traditional approaches to deviant behavior. The traditional methodology has been developed from clinical work and observations of therapy cases. Since procedures were not based upon objective observations, support for theoretical claims was based upon interpretation, intuition, and judgment of the therapist. Thus, neither

the method of evaluation, nor its data were part of a replicable process.

Research in conditioning and comparative psychology stimulated the objective study of behaviour in psychology. Behaviourism, epitomized by the work of John Watson in the early part of this century, made explicit the methodological changes required in psychology and insisted upon the study of overt behaviour rather than private events. Learning became a central topic in psychological study with conditioning providing a means for explaining human and animal learning.

Although Skinner was not the only one to show the importance of response consequences in developing behaviour, he shifted the emphases from respondent to operant conditioning in his account of behaviour. His research elaborated the principles of operant conditioning and at a methodological level Skinner advanced a particular approach for studying and interpreting behaviour, termed the "experimental analysis of behaviour." For Skinner the aim of psychology was not just the understanding of human behaviour, but more importantly its prediction and control. Skinner (1953) viewed the Person as a malleable and manipulatable creature and suggested that "by arranging conditions in ways specified by the laws of a system, we not only predict, we control; we 'cause' an event to occur or assume certain characteristics" (p. 14).

Donahue, Gillis, and King (1980) have stated that throughout the literature on behaviour change there has been a great deal of information concerning motivation and sport (Alderman, 1974), achievement needs and sport participation (Willis and Bethe, 1970),

and skill development (Bilodeau and Bilodeau, 1969). However, these writings have not been used by physical educators or coaches who want to effectively and efficiently develop specific sport and skill behaviour. Nevertheless, Donahue, Gillis, and King (1980) pointed out that research in behaviour change has demonstrated that operant conditioning techniques are the best method for enhancing specific skill development. Similarly, Rushall and Siedentop (1972) proposed that behaviour modification has a great deal to offer coaches for improving the performance of both teams and individuals within sport and physical education.

One of the popular and powerful operant techniques is positive reinforcement. The notion of reinforcement plays a key role Skinner's schema. He regarded an event as a reinforcer if an empirical test demonstrated that it did in fact reinforce, strengthen, or increase a behaviour as a result of being contingent upon it. Outside of their effect he was not concerned with what these events had in common.

Basically, there are two categories of reinforcers. Food, water, sexual contact, and other stimuli whose presentation contingent on a behaviour, strengthens the probability of a response are termed positive reinforcers. On the other hand, a stimulus whose removal, following a response, strengthens that response is a negative reinforcer.

There are two types of positive reinforcers: (1) primary (unconditioned) and (2) secondary (conditioned) reinforcers. A primary reinforcer is an event that can function as a reinforcer without any special training. These are usually events which are

basic to our physical environment. A secondary reinforcer is one which becomes effective as a reinforcer after special training. As a general rule an event that does not function as a positive reinforcer can acquire a reinforcing function by being associated (paired) with something that already is a reinforcer. For example, improvement is probably not a primary reinforcer but it becomes a secondary reinforcer because it is frequently followed by some other reinforcer.

In the physical education and sport setting, several studies have shown the effectiveness of an operant conditioning approach in changing behaviours related to sport skill development. McKenzie and Rushall (1974) confirmed the effect of publicly recording attendance to reduce absenteeism, late arrival, and early leaving from swim practice. They reported that absenteeism was reduced by 43%, tardiness by 63% and that leaving early was completely suppressed.

Scott (1991) employed a lottery incentive system to increase attendance at rugby training sessions. Employing an ABAB design, Scott reported that attendance increased and decreased depending on whether the lottery was operational or not.

To increase the number of positive statements college men made to teammates in a basketball class, Rolider (1978) [cited in Donahue, Gillis and King, 1980] examined the effectiveness of three treatment interventions. It was found that grade incentive was the most powerful intervention, creating a 128% increase in encouraging statements. Teacher modeling produced an increase of 51.9% over baseline. Instruction was the least effective with an increase of 21.1% reported.

A variety of operant strategies have been successful in modifying specific sport skill behaviours. Skills from both individual and team sports, at varying skill levels, have been examined. Individual and team offensive production of nine members of a professional baseball team were the target behaviours in a study which used money as a token system (Heward 1978). Using a withdrawal design, the intervention consisted of monetary rewards to the top three players each week. During the first intervention, the performances of six players were consistently higher than baseline. The performances of four players dropped to baseline levels during withdrawal of reinforcement but these same four players improved their performance during the second intervention.

Wysocki, Hall, Iwata, and Riordan (1979) conducted a programme designed to increase the exercise behaviour of a group of eight college students. The intervention consisted of the subjects depositing items of personal value with the experimenters which would only be returned if an exercise-contract criterion, based on an aerobics points system, was reached. A multiple baseline across subjects design was used and it was found that seven of eight subjects increased the number of aerobic points earned.

In a similar study involving a single subject, Kau and Fisher (1974) demonstrated the efficacy of an operant program to increase jogging behaviour. It was found that following an initial sharp increase from baseline, progress toward the established goal continued to increase. However, the intervention was stopped before the goal was reached, and natural reinforcers began to take over.

The effects of four reward contingencies on the swimming work volume of 32 members of an age-group swimming team was investigated by Rushall and Pettiger (1969). The target behaviour was the number of laps completed and four contingencies were applied: (a) coach's attention, in which a coach gave feedback and encouragement as each work unit was completed; (b) candy, in which one candy was given for each lap completed; (c) money, in which one cent was awarded for each lap completed, and (d) control, in which no predetermined reinforcer was implemented. It was found that candy and money contingencies both resulted in significantly greater lap production than the coach's attention and control contingencies.

The effects of three different reinforcement contingencies on running performance of female basketball players, as part of a preseason conditioning programme, was studied by Birdsong and McCune (1977) [as cited in Donahue, Gillis, and King, 1980]. The target behaviours were mean times on a series of 110 and 220 yard interval runs. In a public recording contingency, times were posted on a board immediately following performance. In a free-time contingency, the last set of intervals was not run if runners matched the performance of the previous day. No planned reinforcement was given in a no reward contingency. Mean performance for both the 110 and 220 yard intervals were faster under this contingency.

Finally, attention and informative feedback were used as reinforcers in a study by Komaki and Barnett (1977). The researchers used a performance checklist to modify the execution of a youth football team. The intervention consisted of the coach providing feedback about correct performance and verbal praise for

successful execution of the play. A multiple baseline design across plays was used, and the results indicated that performance improved after, and not before, each intervention was introduced.

Applied behavioral research has primarily used single-case experimental design, such as the reversal replication and multiple-baseline designs. The changing criterion design is a relatively uncommon single-case methodology. The design has been characterized as a variation of both the multiple baseline design and the reversal replication design. With a changing-criterion design however, the effect of the intervention is demonstrated by showing that behaviour changes occur gradually over the course of the intervention phase, along with changes in a criterion for performance that is specified as part of the intervention (Kazdin, 1982). The required level of performance in a changing-criterion design is altered repeatedly over the course of the intervention to improve performance over time.

The changing-criterion design has been used in the assessment of programs outside the realm of sport and physical education. For example, studies have examined cigarette smoking (Hartmann & Hall, 1976), coffee drinking (Foxx & Rubinoff, 1979) and eating disorders (Sanok & Ascione, 1976). Within physical education, physical fitness has been studied (Taggart, Taggart, & Siedentop, 1986). The purpose of the Taggart, Taggart, and Siedentop study was to train physical education teachers to work with parents, who in turn would plan to increase systematically the activity levels of their low health fitness child. The primary dependent variable in the study was the number of activity points accumulated by subjects (children) each week. The

subjects agreed to a contract on various rewards for attaining increasing weekly points totals. Activity points were calculated by identifying the typical caloric expenditure per minute of the activity and then multiplying this value by the number of minutes of participation. Contingency contract rewards varied for each subject and included money, watching television, and praise. Results of the study revealed an overall mean in baseline of 152 points per week which climbed to an intervention baseline of 304 points per week. This represented a 100 percent increase in activity levels over baseline values.

However, until now this design has not been used in its entirety in the sport environment. However, the nature of the changing criterion design would seem to make it applicable to several sporting situations where step like changes in behaviour are identifiable. The changing-criterion design may not demonstrate experimental control as effectively as the withdrawal or multiple baseline designs, but it does have some advantages over them. It does not require the reversal behavior of the withdrawal design, a procedure which is often difficult in the sport setting. Furthermore, it does not require multiple independent behaviours, subjects, or situations, as do the standard multiple baseline designs. Finally this design is perfectly suited to the step like systematic increases that occur in the application of shaping to physical skill improvement.

In the present study the changing-criterion design employed changes in the speed of videotape viewing with informative feedback and improvement in performance presumed to act as reinforcers.

Starkes and Lindley (1994) reported that structured video tape training can be a useful supplement to regular physical practice and in a follow up study they reported that video simulation resulted in a significant decrease in decision-making time for an experimental group. However, Lindley (1987) reported that simulation had no effect on the accuracy of responses and that studies in the area had experienced difficulties in evaluating possible trained effects in the real setting.

The present study addressed a number of problems. Up until now studies in the area have been short (six-week duration), group in nature, and have struggled to effectively measure and evaluate effects in a "real" environment. The present study examined: the difference in accuracy of prediction between advanced and intermediate players as a function of speed of video-taped simulation of tennis serves, the effect of individual training programs over a prolonged period of time, and transfer effects to the "real environment."

Hypotheses

To fulfill the purposes of the study the following directional hypotheses were tested:

Experiment 1

1. (All subjects)

Based on the assumption that differences in performance between advanced and intermediate players may result from variations in information processing skills in a time pressure situation, and that given enough time intermediate players will be able to process the relevant information, the following hypothesis was tested:

There will be no significant difference between advanced and intermediate tennis players in total prediction scores, for depth, width, and type of tennis serve at slow play speed.

(1a). There will be no significant difference between advanced and intermediate tennis players in serve type prediction scores.

(1b). There will be no significant difference between advanced and intermediate tennis players in serve depth prediction scores.

(1c). There will be no significant difference between advanced and intermediate tennis players in serve width prediction scores.

2. (All subjects).

Based on the assumption that differences in performance between advanced and intermediate players may result from variations in information processing skills in a time pressure situation, the following hypothesis was tested:

There will be a significant difference between advanced and intermediate tennis players in total prediction scores for type, depth, and width, of tennis serve at regular play speed.

3. (Advanced only)

Based on the assumption that advanced players possess superior information processing skills at normal speed play it would be expected that they would retain this skill at slow speed play.

Consequently, the following hypothesis was tested:

There will be a significant relationship between slow and regular play speed prediction scores for advanced tennis players in type, depth, and width of tennis serve.

4. (Intermediate players only)

Based on the assumption that intermediate players do not possess superior information processing skills at normal speed play, as opposed slow speed play, the following hypothesis was tested:

There will be no significant relationship between slow and regular play speed prediction scores for intermediate tennis players in type, depth, and width of tennis serve.

Experiment 2

5. Based on the assumption that there would be a transfer in training effect from video play to on-court performance the following hypothesis was tested:

There will be a significant difference between pre and post treatment scores with regard to on court serve return performance.

This difference will be facilitated by a modified changing-criterion design where the effect of the video intervention will be demonstrated by showing that accuracy prediction gradually changed over the course of the intervention.

CHAPTER III

Research Methods, Results, and Discussion of Experiment I

Subjects

The subjects in this study were 38 volunteer tennis players from Victoria, British Columbia and St. Catharines, Ontario. The group consisted of equal numbers of males and females and all subjects were over the age of nineteen.

All subjects were classified by local coaches as intermediate (n=20) or advanced (n=18)}. Intermediate tennis players were identified as those athletes who had intermediate skills, were regular recreational tennis players and who did not represent their province or participate in provincial-level competition. Advanced tennis players were provincially ranked or judged to possess superior technical skills. All advanced players had played in provincial level competitions.

The permission of the coaches, where appropriate, was obtained as was the consent of each individual player (see Appendix). All players had the option of withdrawing from the project at any time.

Procedure

Film Construction. Subjects were required to view a prepared film which was constructed in the following manner. A video camera containing high speed film was positioned on the right side of the court baseline, one meter from the singles court side line, and set to a height of 1.70 meters above court level. It focused on the server,

who served from the center line on the other baseline to the right serve receive box. The content of the film consisted of 108 serves with each one being performed by the same elite tennis player. The total of 108 serves were made up of a cycle of 18 different serves with the cycle being repeated six times. Neither the server, order, or speed of serve varied across the cycle. There were three different types of serve (flat, top spin, and sliced), two differing depths of serve (shallow and deep), and three different landing positions (center line, middle of the receiving court, and singles side line).

Subject Testing. Each subject was asked to sit three meters away from a 26 inch television monitor in a well lit room. At the commencement of the test each subject was permitted to view an example of each type of serve; a total of 18 serves. Each type of serve was shown once and for each sample serve subjects were told the type, depth, and landing zone. In addition, subjects were advised of pertinent advance cues which accompanied each serve. Nine of these sample serves were shown in slow speed and the other nine at regular speed. During the test each serve began five seconds prior to contact and occlusion occurred on racquet/ball contact. Subjects were asked to predict the type, depth, and landing zone of each of the remaining 90 serves and were requested to give a verbal response immediately following the occlusion of each serve. Each subject viewed the tape at normal speed and at slow speed (1/30 of regular speed). The order of play speed alternated from subject to subject and example serves were played prior to viewing the film at each speed.

Prediction Scoring. The subject was required to identify the type of serve, the depth of serve, and the location of the landing zone. For each part of a serve identified correctly a subject was awarded one point. Thus a correctly predicted serve was worth three points (serve type, depth and width all being correctly identified) and a total of ninety correctly predicted serves produced 270 points.

Data Analysis

A randomised block two way Level X Order analysis of variance (ANOVA) was used to establish if there was a significant difference in performance as a result of viewing order. A second one-way Level X Speed ANOVA (2 X 2), with post hoc Scheffés, was used to establish if there was a significant difference in performance between advanced and intermediate players in prediction accuracy of serve at slow and regular speed. A Pearson's Product Moment Coefficient of Correlation was used to determine the correlation between scores on type, depth, and width for each speed within each level of expertise. Finally Mann-Whitney U tests were employed to determine the extent of separation between advanced and intermediate players on type, depth, and width of serve within each speed.

Results and Discussion

The results of this study are reported according to the research hypotheses outlined in Chapter II. The means, standard deviations, and levels of significant differences for advanced and intermediate

players prediction scores and order of viewing are presented in Table 1.

Although two different orders of play speed were used during Experiment 1, an analysis of variance indicated that there was no main effect for viewing order $F(3, 34) = 0.50, p > .05$. The results of the study did reveal a significant main effect for level $F(3, 34) = 327.10, p < .001$, but no significant interaction effect for order and level $F(3, 34) = .19, p > .05$. These results are shown in Table 2.

1. (All subjects)

There will be no significant difference between advanced and intermediate tennis players in total prediction at slow play speed.

(1a). There will be no significant difference between advanced and intermediate tennis players in serve type prediction scores at slow play speed.

(1b). There will be no significant difference between advanced and intermediate tennis players in serve depth prediction scores at slow play speed.

(1c). There will be no significant difference between advanced and intermediate tennis players in serve width prediction scores at slow play speed.

2. (All subjects).

There will be a significant difference between advanced and intermediate tennis players in total prediction scores for type, depth, and width of tennis serve at regular play speed.

Table 1

Means and Standard Deviations for Viewing Order
Prediction Totals for Advanced and Intermediate Players

Order	n	M	SD
<u>Intermediate</u>			
Slow 1st	10	204	4.50
Slow 2nd	10	203.5	6.08
Regular 1st	10	161.4	4.88
Regular 2nd	10	157	8.10
<u>Advanced</u>			
Slow 1st	9	214	7.25
Slow 2nd	9	212	4.10
Regular 1st	9	200.11	6.57
Regular 2nd	9	201.22	6.00

Table 2

F Values for Advanced and Intermediate Players Prediction Scores at Slow and Regular Speed

Source	F Value	P
Order	0.50	.49
Level	327.10	.0001*
Level & Order	0.19	.68

Note: df = 3, 34; *p > .001.

The means and standard deviations for advanced and intermediate players for prediction scores for total, type, depth, and width of tennis serves at slow and regular speed are presented in Table 3 and Figures 1, 2, 3 and 4.

An analysis of variance between advanced and intermediate players for total accuracy prediction at slow and regular speed revealed a significant main effect for level, $F(3, 72) = 309.63, p < .001$, a significant main effect for speed, $F(3, 72) = 436.56, p < .001$, and a significant interaction effect, $F(3, 72) = 126.84, p < .001$. Subsequent post hoc Scheffé analyses revealed a significant difference between advanced and intermediate players at slow speed $F(3, 72) = 23.22, p < .001$ and also at regular speed $F(3, 72) = 433.78, p < .001$. These results are presented in Table 4.

In a secondary question, developed a posteriori, the researcher attempted to determine if advanced players always scored higher in each of the sub components of the total, that is, serve type, serve depth, and serve width. A Mann Whitney non parametric test was applied to the data. The Mann Whitney U test analysed the separation between advanced and intermediate scores on each component at both speeds. The results allowed one to determine the probability of achieving the obtained separation. The more separated the sample scores, the less reasonable it is to conclude that chance is responsible for the separation. The Mann Whitney U scores between advanced and intermediate players on type, depth, and width of tennis serves at slow and regular speed are presented in Table 5.

The results of the Mann-Whitney test revealed a significant difference in the degree of separation between advanced and

Table 3

Means and Standard Deviations of Advanced and Intermediate Players Prediction Scores for Type, Depth, and Width of Tennis Serve at Slow and Regular Speed.

	Type	Depth	Width	Total
<u>Advanced (Slow)</u>				
M	69.83	64.89	78.67	213.75
SD	3.07	4.10	3.55	5.79
<u>Intermediates (Slow)</u>				
M	66.65	61.85	75.85	203.75
SD	2.32	4.54	4.23	5.41
<u>Advanced (Reg.)</u>				
M	65.50	62.05	73.11	200.39
SD	3.58	4.79	3.80	5.88
<u>Intermediates (Reg.)</u>				
M	41.40	57.40	60.40	158.25
SD	3.69	4.23	4.17	7.53

Figure 1. Type, Depth, Width, and Total Prediction Accuracy for Advanced Players at Regular Speed

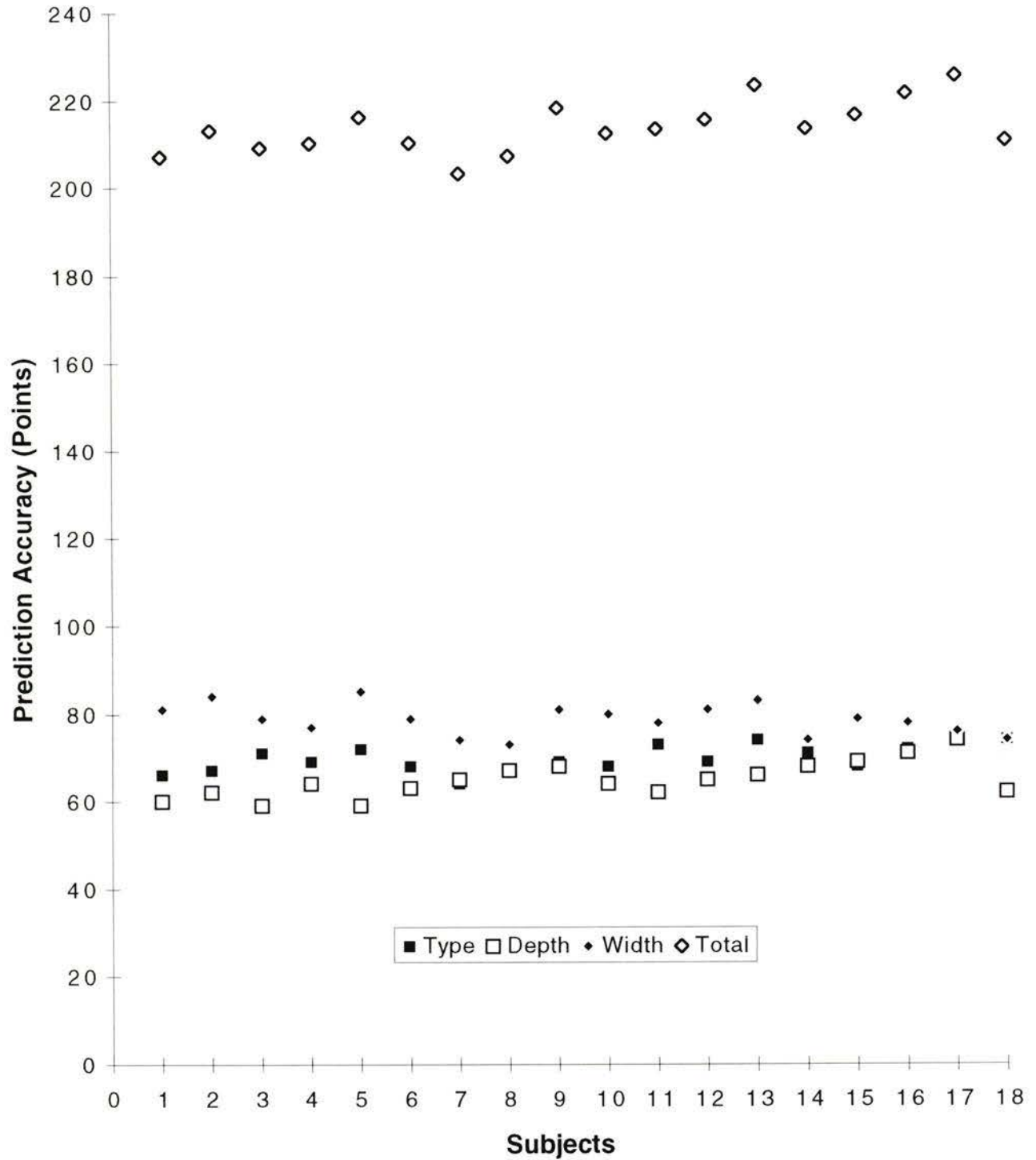


Figure 2. Type, Depth, Width, and Total Prediction Accuracy for Intermediate Players at Regular Speed

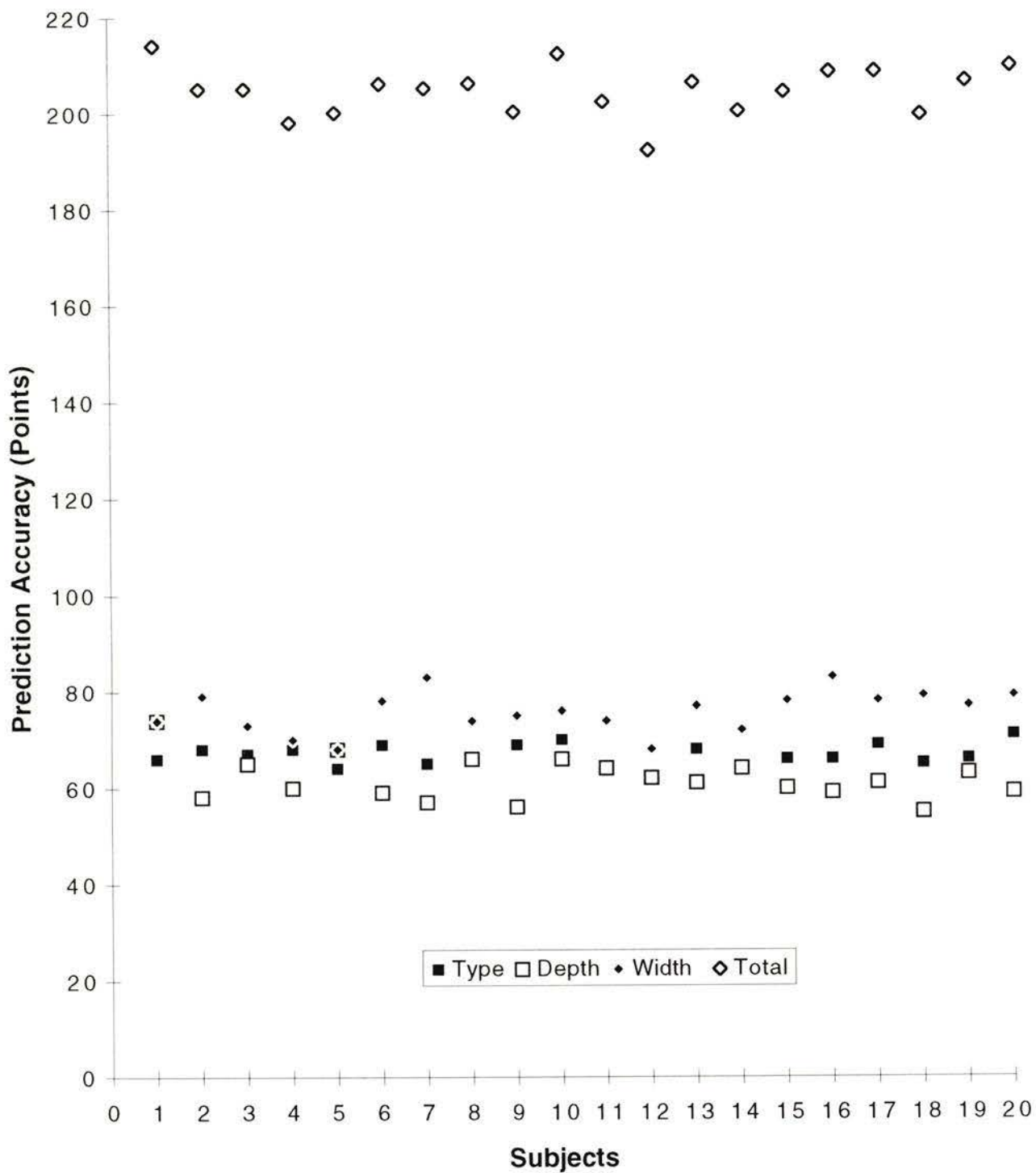


Figure 3. Type, Depth, Width, and Total Prediction Accuracy for Advanced Players at Slow Speed

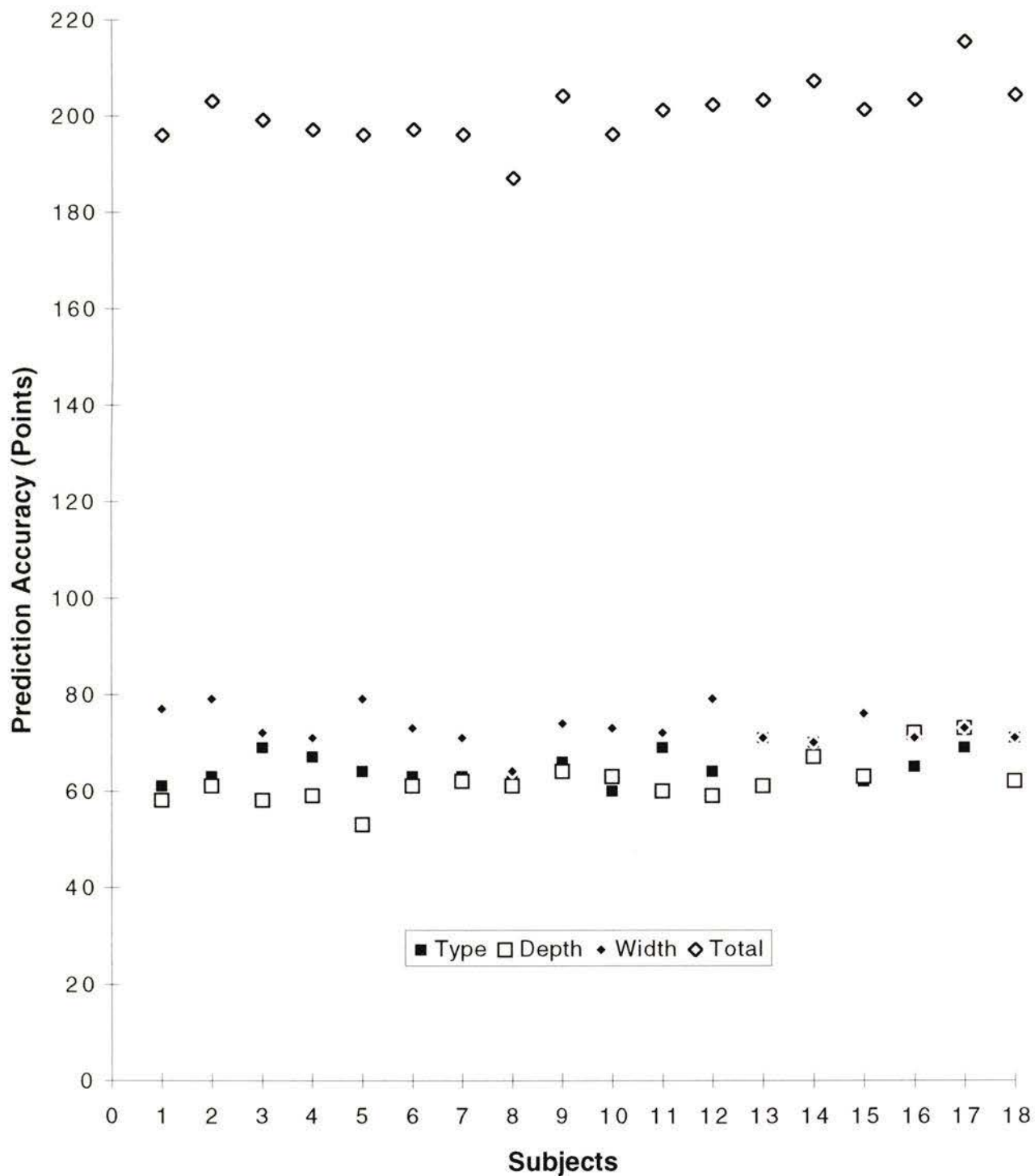


Figure 4. Type, Depth, Width, and Total Prediction Accuracy for Intermediate Players at Slow Speed

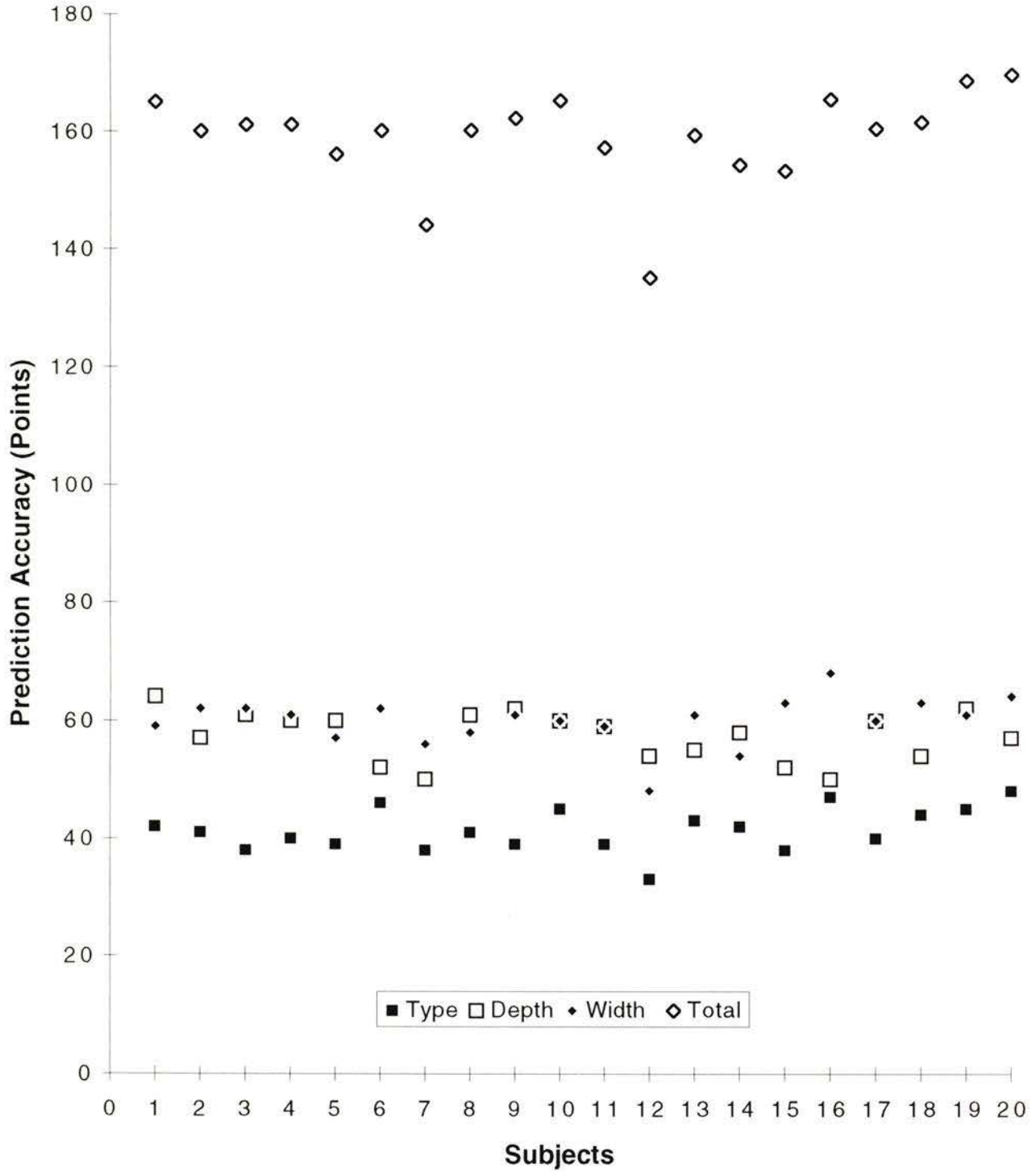


Table 4
F Values and Post Hoc Scheffés for Advanced and Intermediate Players on Total Prediction Accuracy at Slow and Regular Speeds.

Condition	F	Post Hoc Scheffé
Level	309.63*	
Speed	436.56*	
Level & Speed	126.84*	
Advanced and Intermediates (Slow Speed)		23.22*
Advanced and Intermediates (Reg. Speed)		433.78*

Note : * $p < .001$

Table 5

Mann-Whitney U Values for Advanced and Intermediate Players Prediction Scores of Type, Depth, and Width of Serve at Slow and Regular Speed.

	Type	Depth	Width
<u>Slow Speed</u>			
Mann-Whitney U	112/323*	124/273	131/279
<u>Regular Speed</u>			
Mann-Whitney U	0/380*	106/297*	2/373*

Note. *Scores are significantly separate at $p < .05$.

intermediate players for serve type at slow speed, $U(20, 18) = 112/323$, $p < .05$; and between advanced and intermediate players with regard to type, $U(20,18) = 0/380$, $p < .05$; depth, $U(20,18) = 106/297$; $p < .05$; and width, $U(20,18) = 2/373$ $p < .05$ at regular speed. No significant degree of separation was found between advanced and intermediate players in regard to serve depth or width at slow speed.

Performance percentages for the prediction of serve type, depth, width and totals for advanced and intermediate players are presented in Table 6. This is based on the number of correctly identified serves from a total of 90 serves. Chance levels were based on the number of selections required: type and width, 1 from 3 or 33%; depth 1 from 2 or 50%.

Serve type, depth, width, and total accuracy prediction scores for advanced and intermediate players at slow and regular speed are presented in Figures 5, 6, 7, 8, 9, 10, 11 and 12.

The results of this study rejected the hypotheses that there would not be a significant difference in prediction accuracy between advanced and intermediate players for total serve prediction and serve type prediction at slow speed. However, post hoc analysis did support the hypotheses that there would not be a significant difference in prediction accuracy between advanced and intermediate players for total serve prediction and serve type prediction at slow speed. However, although a significant difference still remained between the groups for total accuracy prediction, it should be noted that intermediate players benefited more than

Table 6

Performance Percentages and Percentage Improvement for Prediction Accuracy by Advanced and Intermediate Players at Slow and Regular Speed

	Type	Depth	Width	Total
<u>Slow</u>				
Advanced	77	72	87	79
Intermediates	74	69	84	75
<u>Regular</u>				
Advanced	73	69	81	74
Intermediates	46	64	67	59
<u>Improvement</u>				
Advanced	4	3	6	5
Intermediates	28	5	17	16

Note. Chance levels for Type = 33% (1/3); Depth = 50% (1/2); Width = 33% (1/3); and Total = 43%

Figure 5. Serve Type Prediction Accuracy for Advanced and Intermediate Players at Slow speed

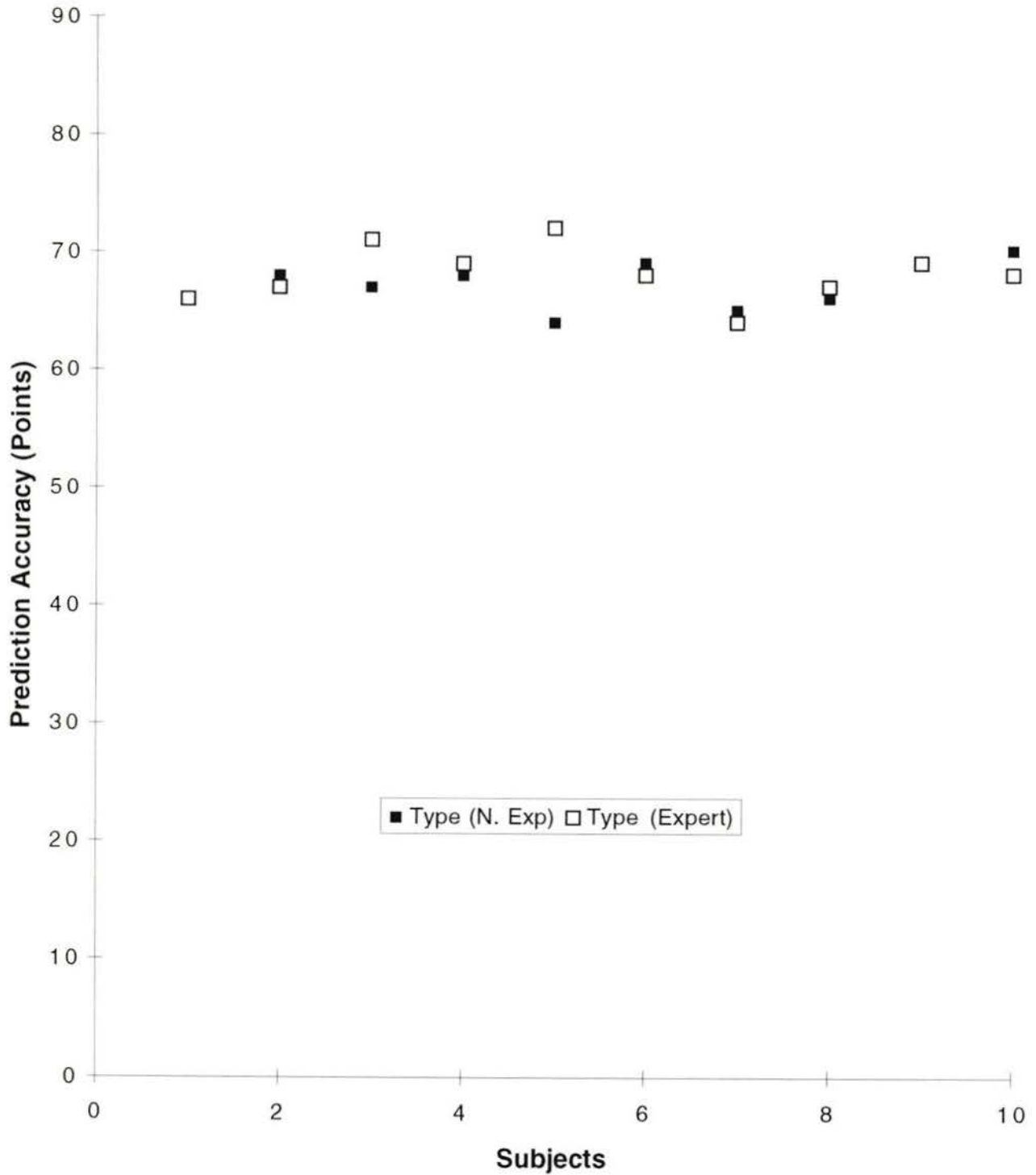


Figure 6. Serve Depth Prediction Accuracy for Advanced and Intermediate Players at Slow Speed

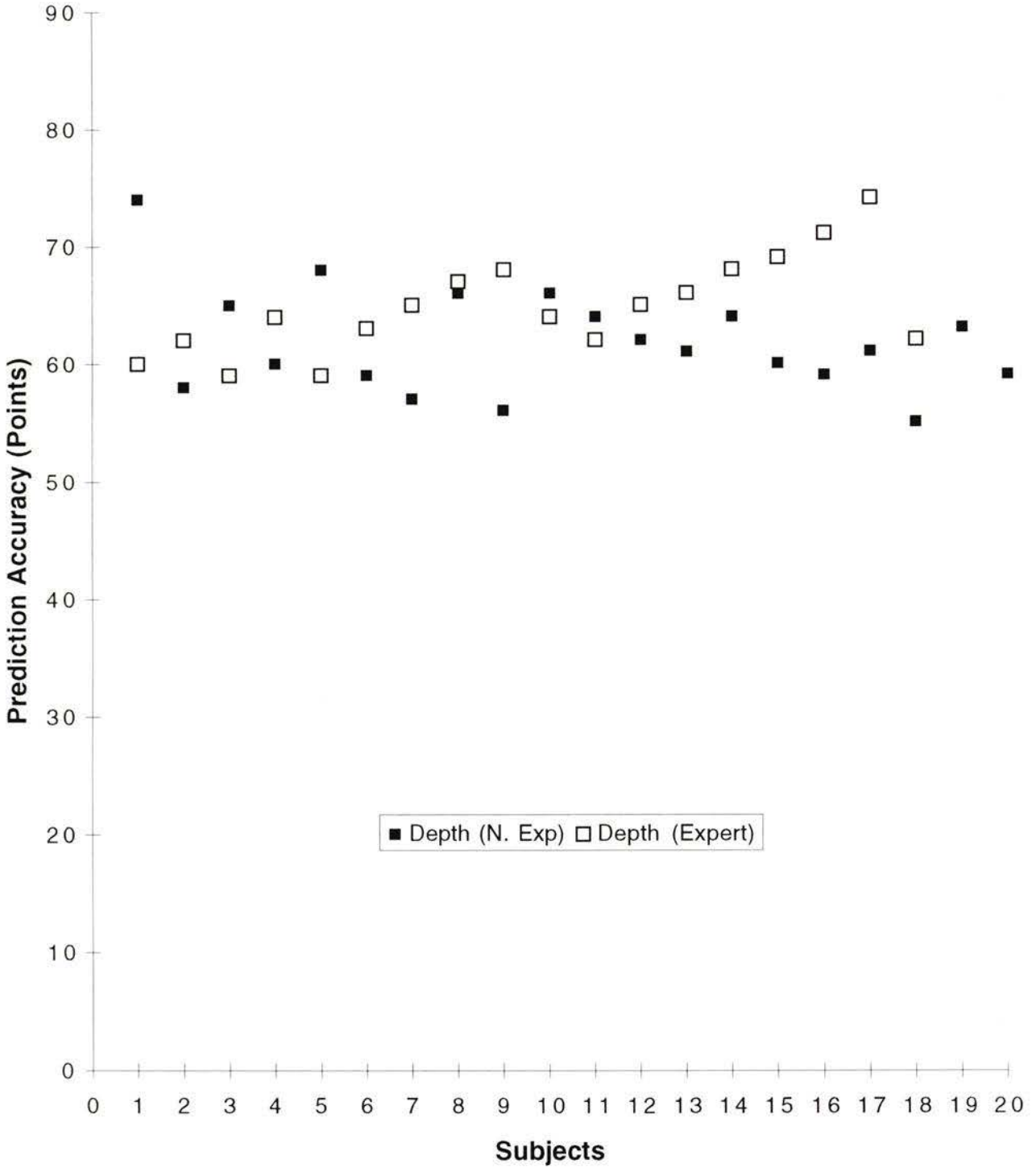


Figure 7. Serve Width Prediction Accuracy for Advanced and Intermediate Players at Slow speed

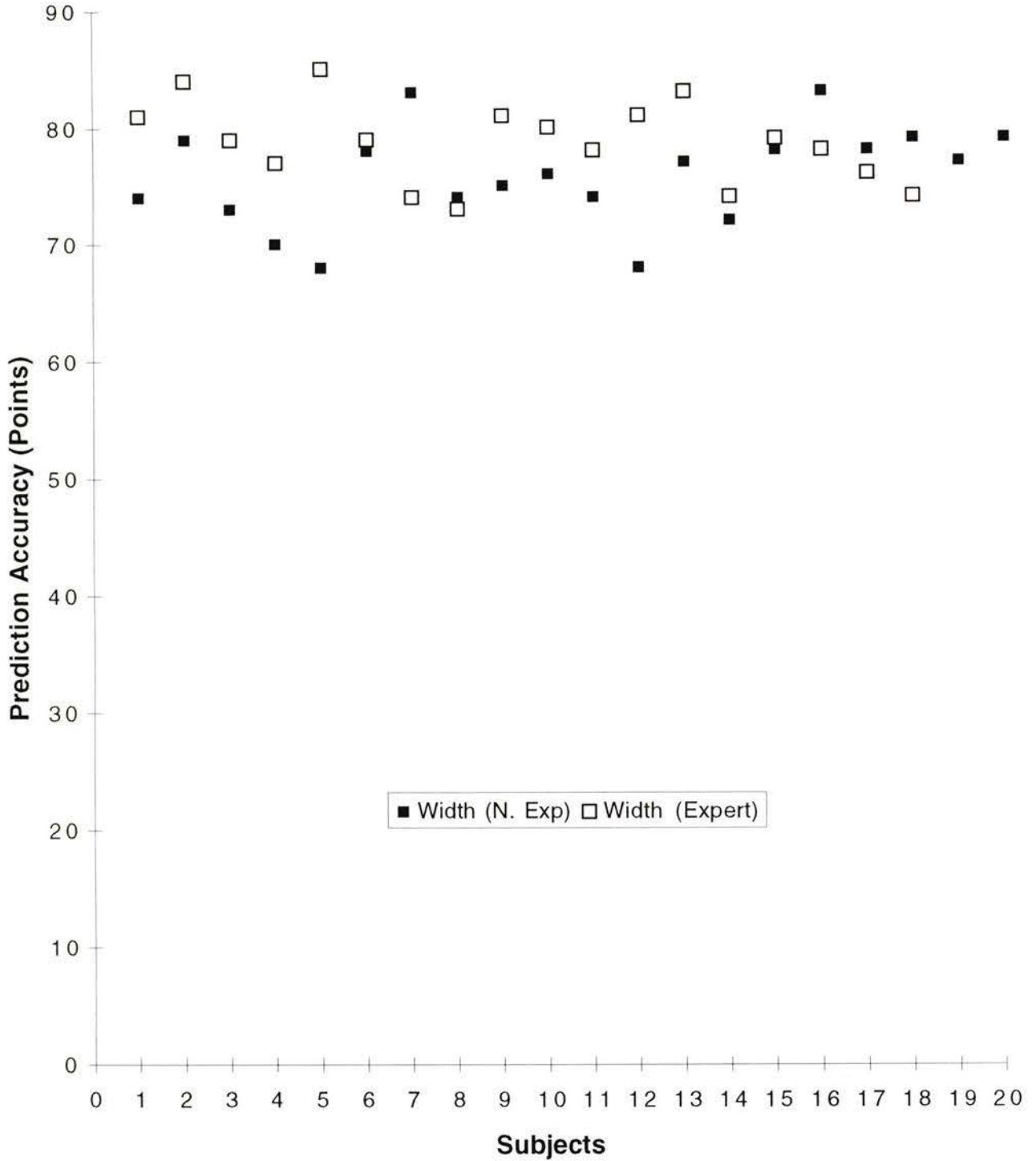


Figure 8. Total serve Prediction Accuracy for Advanced and Intermediate Players at Slow Speed

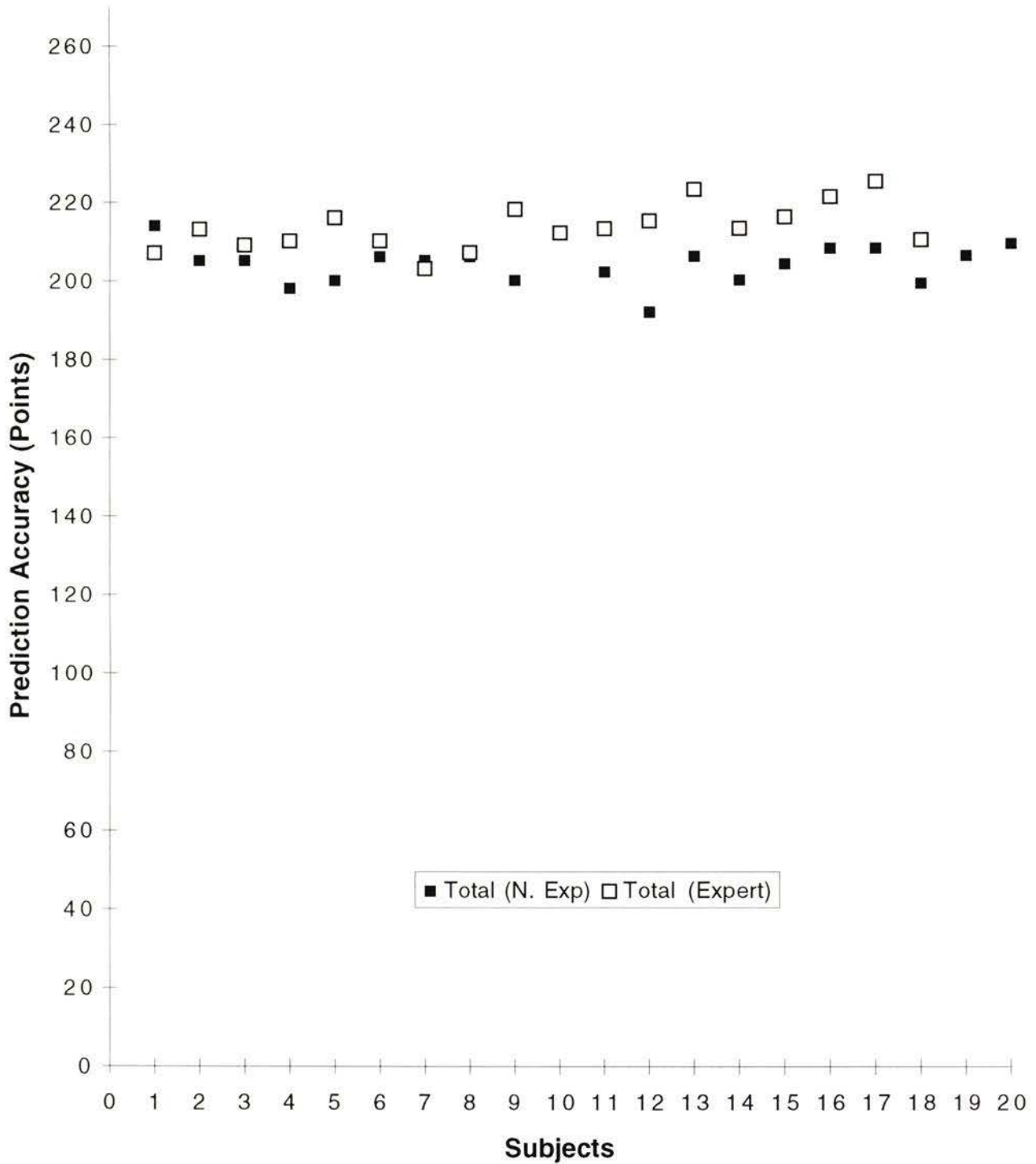


Figure 9. Serve Type Prediction Accuracy for Advanced and Intermediate Players at Regular Speed

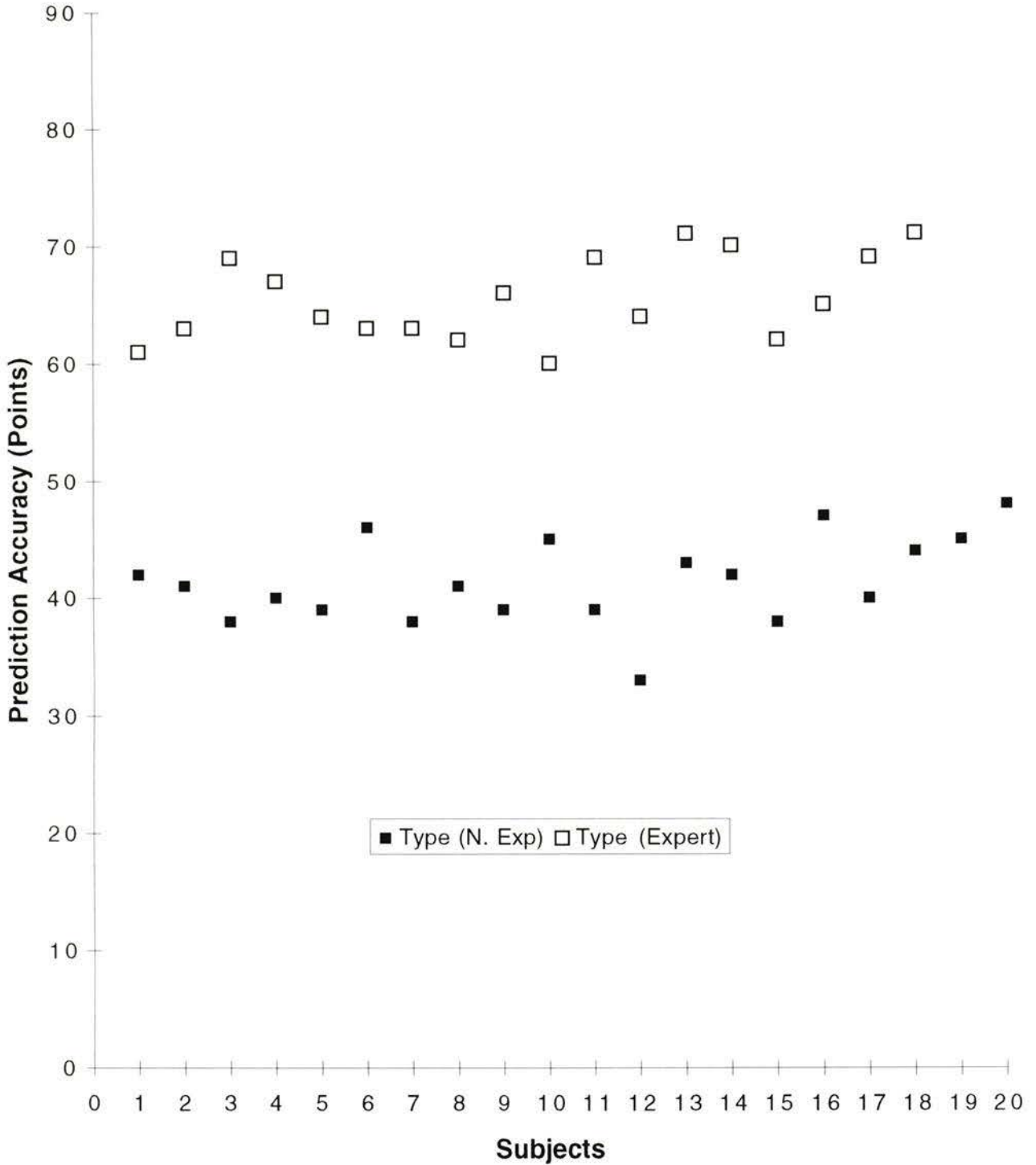


Figure 10. Serve Depth Prediction Accuracy for Experts and Non Experts at Regular Speed

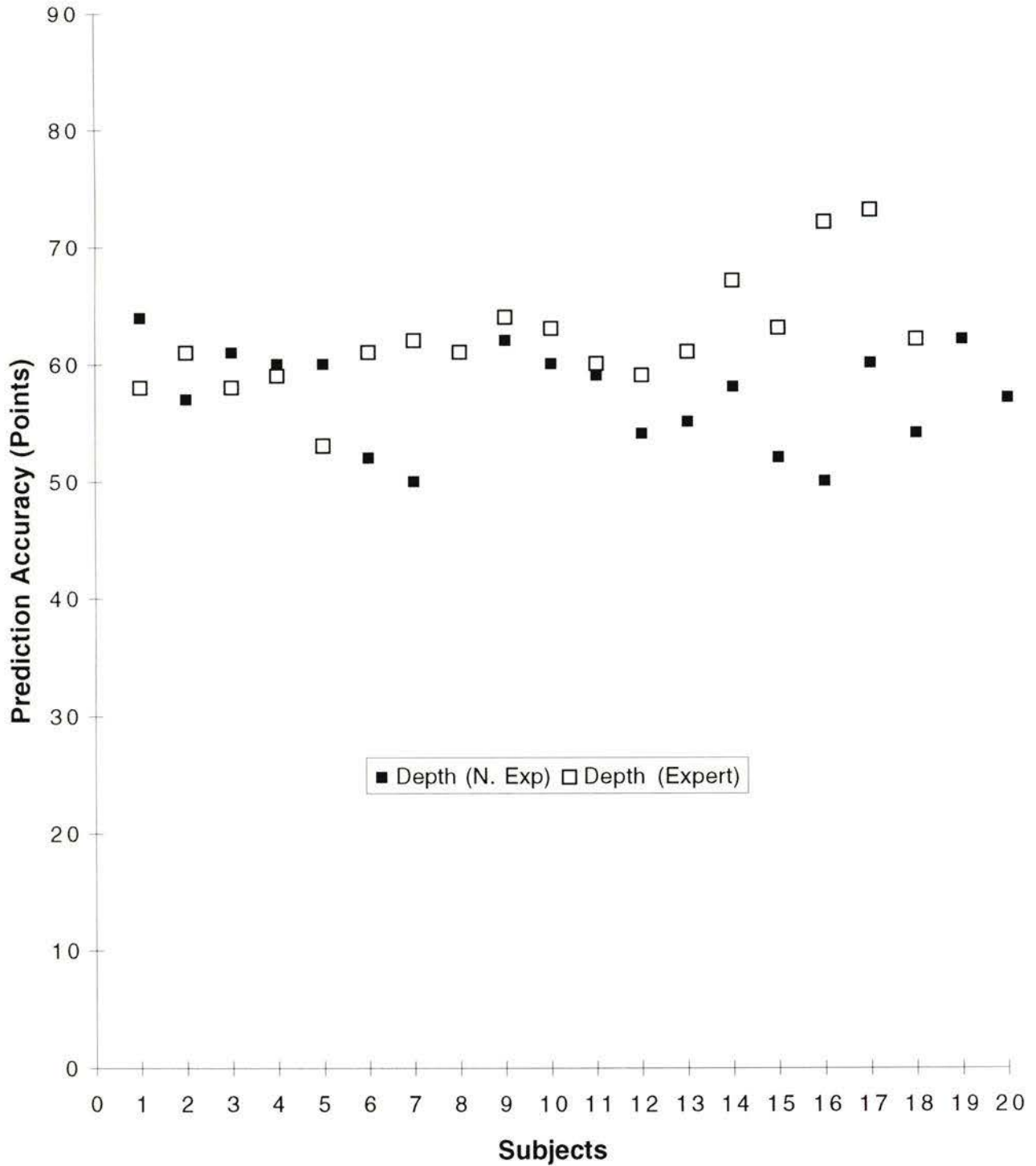


Figure 11. Serve Width Prediction Accuracy for Advanced and Intermediate Players at Regular Speed

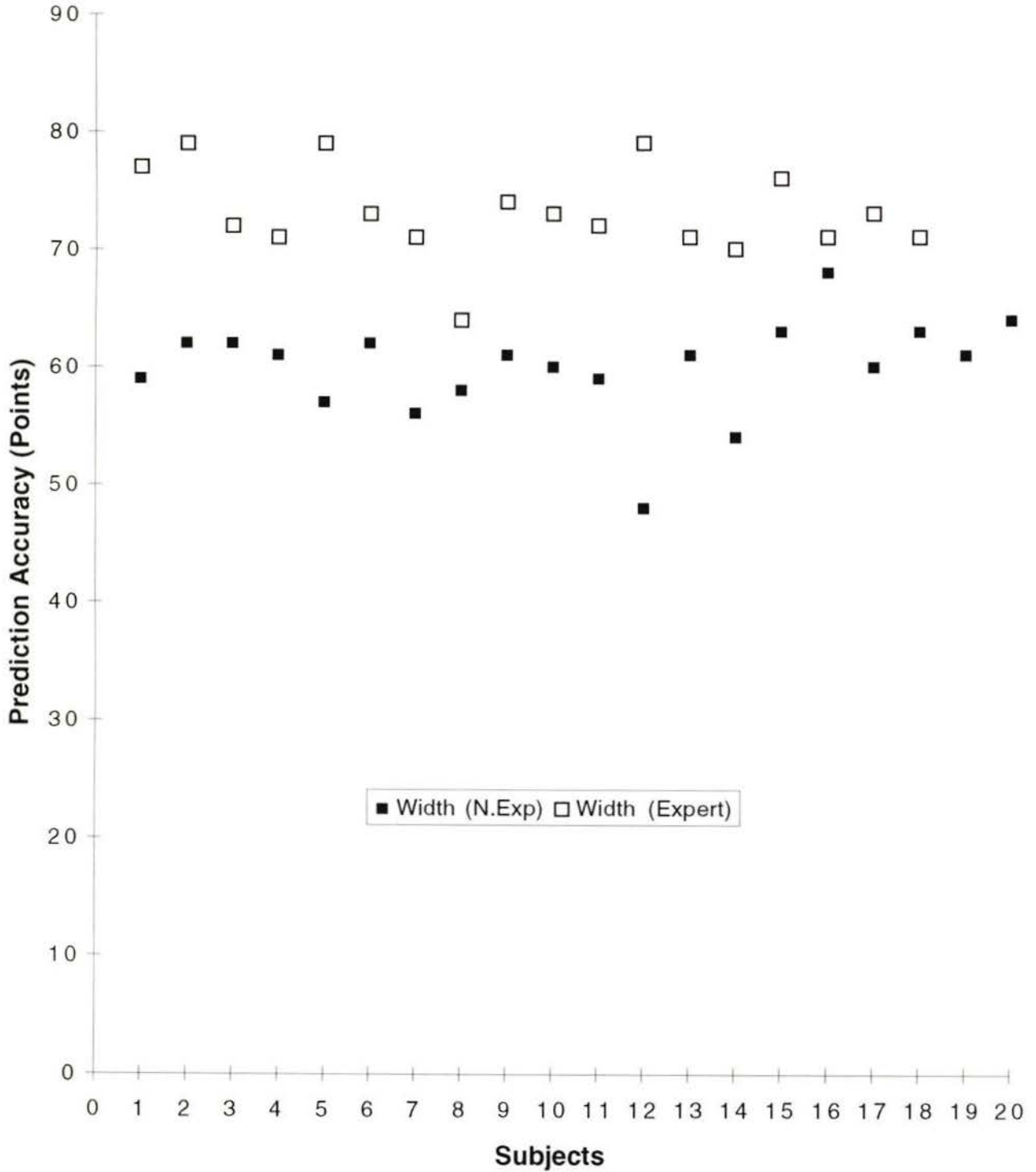
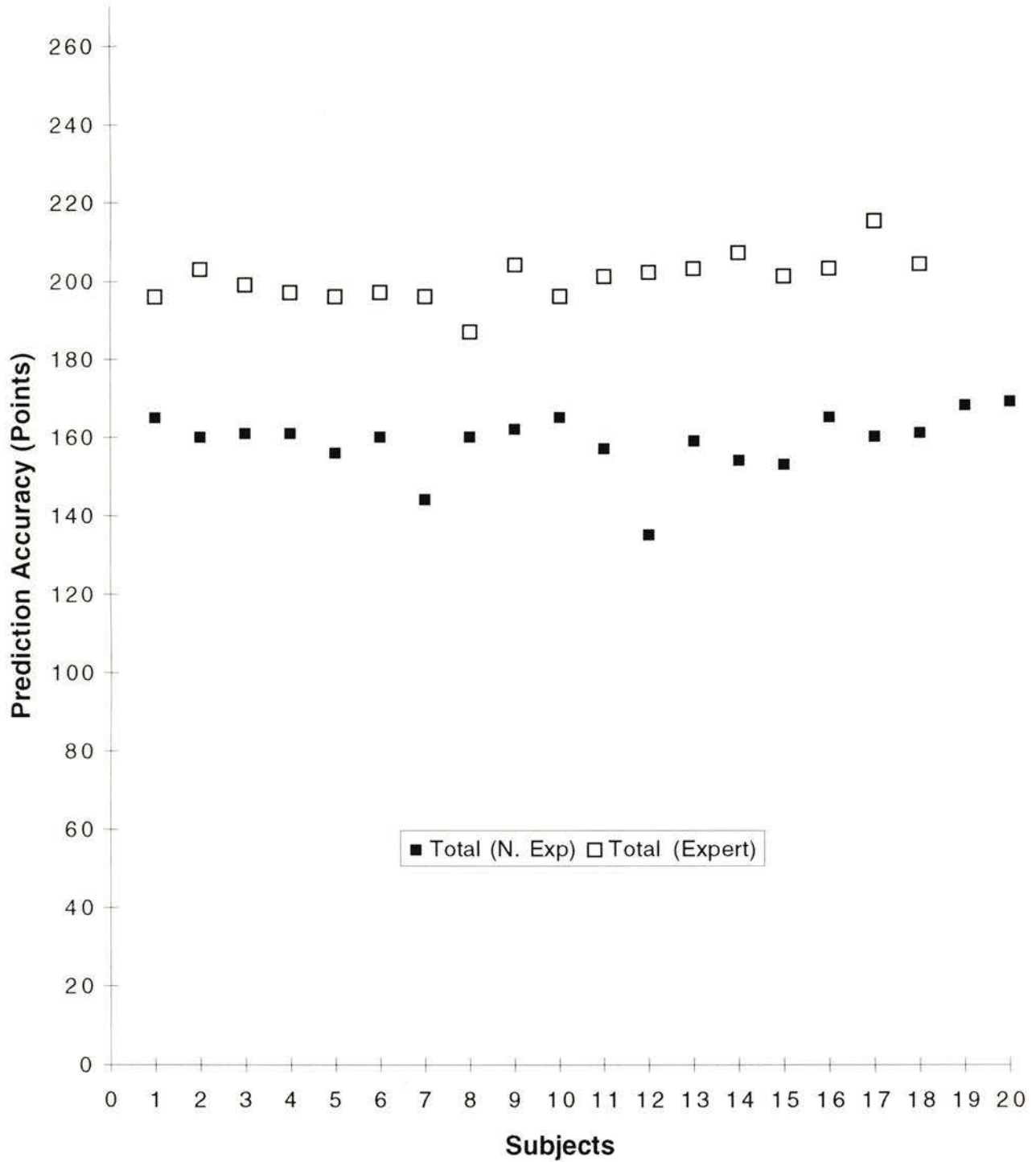


Figure 12. Total Serve Prediction Accuracy for Advanced and Intermediate Players at Regular Speed



advanced players from the playing of the video at slow speed. This can be seen in the significant level by speed interaction and more clearly in Table 6 where intermediate players demonstrated a substantially greater improvement in scores at slow speed in comparison to regular speed.

In a study dealing with the prediction of passing shots Buckolz, Prapavesis, and Fairs (1988) reported that prediction accuracy differences between intermediate and advanced players did not arise because intermediate players were unaware of the relevant cues. They suggested that intermediate players seemed less able to detect the presence of advance cues quickly or consistently. Should this be the case then one might expect intermediate players to benefit more than advanced players from the slowing down of a priori information. In regard to the present study this would seem to be the case. The results of this study would suggest that the greater rate of improvement for the intermediate players came from the increased frequency with which they were able to detect the presence of reliable, advance cues

An ANOVA and post hoc Scheffé revealed a significant difference between advanced and intermediate players at slow speed. The level of difference was not as great as that found with regular speed which lends some support to the notion that slower play speed permitted more time for cue identification. This in turn directly lead to increased performance on the part of the intermediate players.

A Mann Whitney U test revealed a significant amount of separation between advanced and intermediate players in regard to

serve type but not with regard to serve depth or serve width at slow speed.

Both advanced and intermediate players recorded small increases in prediction performance for serve depth at slow versus regular speed. For both groups, evaluation of depth proved to be the most difficult component of the serve to predict. This may have resulted from a lack of advance cues on the part of the server, perhaps because both advanced and intermediate players utilize post racquet ball contact cues. Since these cues were missing, both groups may have lacked the consistent ability to identify and process advance depth cues. However, it should be noted that both groups, while finding this component the most difficult to predict, still performed at a better-than-chance level. This would suggest that advance cues were available. What is in doubt is whether this relatively poor performance resulted simply from a lack of ability of advanced and intermediate players to consistently identify and process these cues, or from a lack of consistency on the part of the server in producing these cues.

Prediction of serve width was completed at a high success rate for both groups. It is clear that this component of the serve was the one that both advanced and intermediate players found easiest to predict. As with serve type, intermediate players demonstrated substantial prediction improvement from regular to slow play speed and seemed to have benefited from the additional time allowed during slow play speed for serve identification and processing. These high levels of performance by both groups may have been further aided by the nature of the advance cues associated with serve width.

These cues, on the part of the server may have been harder to disguise than those of serve type and may therefore have been easier for the receiver to identify and process.

The results of this study support the hypothesis that there would be a significant difference in prediction accuracy between advanced and intermediate players for type, depth, width, and total serves at regular play speed. The results confirm previous research findings that advanced players identify more serves correctly than intermediate players and that advanced players may use more accurate decision-making processes than intermediate players.

Considering that only a priori information was available, advanced and intermediate players performed at a level well above that of chance. This would suggest that advance cues were available which accurately forecast serve type, depth and width. This result may also add some support to the suggestion that advanced and intermediate players may have equal theoretical knowledge of which advance cues are relevant but that they differ in their ability to detect and/or process these cues. For advanced players, the level of prediction was quite high, suggesting that a priori cues were indeed useful, especially when noting that failure to detect the type, depth, or width of serve could lead directly to the loss of a point or points. For intermediate players, the level of prediction at regular speed was somewhat lower than those of the advanced group but was still at a better-than-chance level.

Not only did advanced and intermediate players differ in their levels of prediction, they also differed in their relative ability to predict specific aspects of the serve. This can be seen clearly in

Figures 9, 10, 11, 12 and in Table 5. Advanced and intermediate players demonstrated the least amount of difference in regard to depth and the most with regard to type. It is interesting to note that the least amount of difference occurred for depth. Many subjects, both advanced and intermediate players, reported depth to be the most difficult component to detect. With regard to depth it should be noted that there were only two choices (shallow or deep). Therefore the chance level was fifty and this may have served to exaggerate absolute scores. For example advanced players were 40% above chance with regard to type of serve prediction, 48% for width, but only 19% for depth. At the same time intermediate players were 13% above chance for type, 34 % for width, and 14% for depth. These results confirm the difficulty expressed by both groups and would suggest that a priori cues had little influence for both advanced and intermediate players with respect to depth prediction. This in turn would suggest that depth prediction is strongly dependent on post contact cues.

Figures 1 and 2 clearly demonstrate that the greatest difference between advanced and intermediate players was to be found in regard to serve type prediction. Intermediate players found serve type the most difficult component to predict whereas advanced players were reasonably adept at predicting serve type. There may be a number of reasons for this. First, with regard to type of serve there would seem to be a number of important advance cues. These include differing body and racquet positions for different serves. It may have been the case that intermediate players selected and/or processed the wrong cues. Goulet, Bard and Fleury (1989) reported

that in preparing to return a serve, advanced and intermediate players use different scanpaths. They revealed that advanced players use cues associated with the general body position of the server whereas intermediate players focused on the server's head. Advanced players used information issued from the racquet and from the arm holding the racquet. Intermediate players, on the other hand focused almost entirely on the ball. According to Goulet, Bard, and Fleury (1989) this difference in visual search strategy could help explain the difference in the number of correctly identified serves. It would therefore follow that knowledge of the most informative cues, with regard to serve type, is imperative.

Another variable that may contribute to differences in performance between advanced and intermediate players with regard to serve type prediction is information-processing speed. Intermediate players may well have knowledge of, or be given knowledge about, important advance cues. However, if not only their detecting, but also their processing of these cues in a time constraint situation is slow, their resulting performance, in comparison to advanced players, will be poorer. In regard to serve type prediction it may well have been the case that the number of important advance cues to process was more than in serve depth and width. This coupled with an intermediate slowness in serve detection and information-processing would have resulted in poorer performance. This suggestion is supported by Buckolz, Prapavesis, and Fairs (1988). In their study which examined the use of advance cues and the passing shots of advanced and intermediate players, it was revealed that both advanced and intermediate players reported

using the same cues. It was suggested by the researchers that while intermediate players knew which cues to look for, they were less efficient than advanced players in detecting their presence under regular speed conditions.

In terms of prediction accuracy both advanced and intermediate players did best in regard to serve width. The advance cues which went with each serve width were few and relatively clear and as a result prediction performance was good for both groups. It should be noted however, that advanced players still predicted at a level significantly greater than that of intermediate players.

3. *(Advanced only)*

There will be a significant relationship between slow and regular play speed prediction scores for advanced tennis players in type, depth, width, and total serve.

Prediction accuracy for type, depth, width and total serve by each advanced subject, at slow and regular speed, are presented in Figures 13, 14, 15, and 16.

Pearson's product moment coefficient of correlation revealed significant relationships between serve type prediction by advanced players at slow and regular speed, $r(36) = .798$, $p < .05$; serve depth prediction by advanced players at slow and regular speed, $r(36) = .870$, $p < .05$; serve width prediction by advanced players at slow and regular speed, $r(36) = .770$, $p < .05$; and total serve prediction by advanced players at slow and regular speed, $r(36) = .703$, $p < .05$. These results are presented in Table 7.

Figure 13. Prediction Accuracy for Serve Type at Slow and Regular Speed by Advanced Players

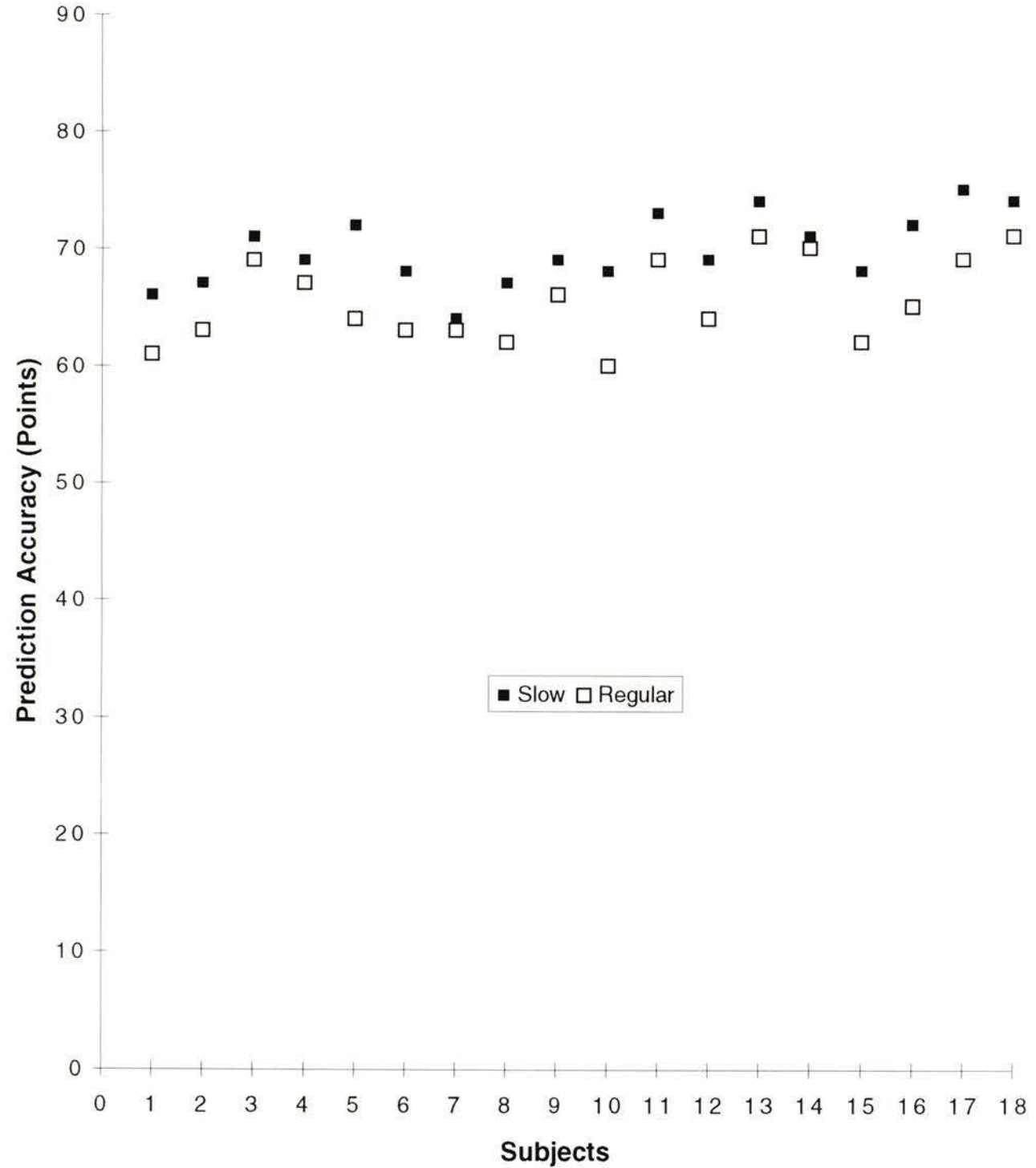


Figure 14. Prediction Accuracy for Serve Depth at Slow and Regular Speed for Advanced Players

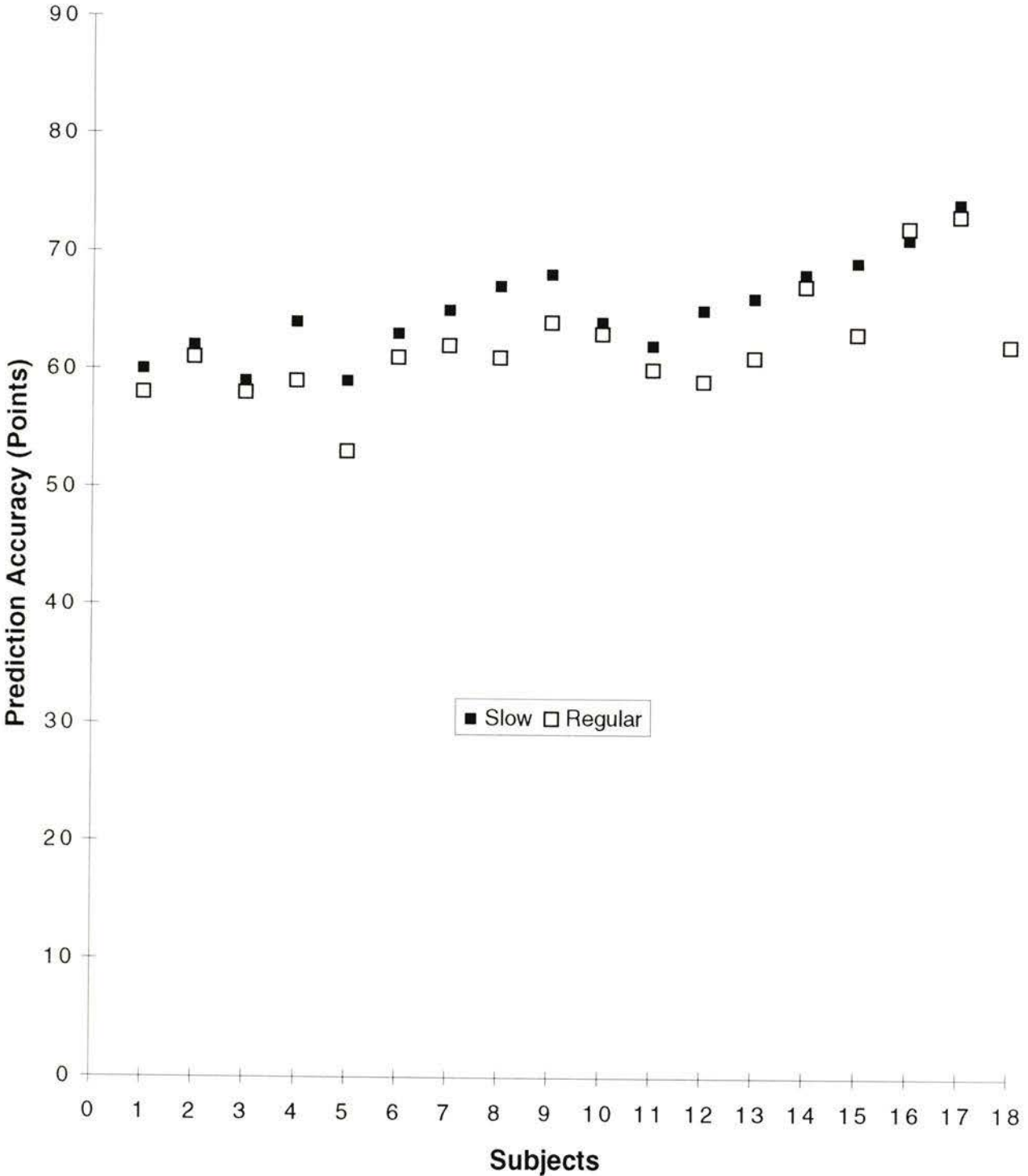


Figure 15. Prediction Accuracy for Serve Width at Slow and Regular Speed by Advanced Players

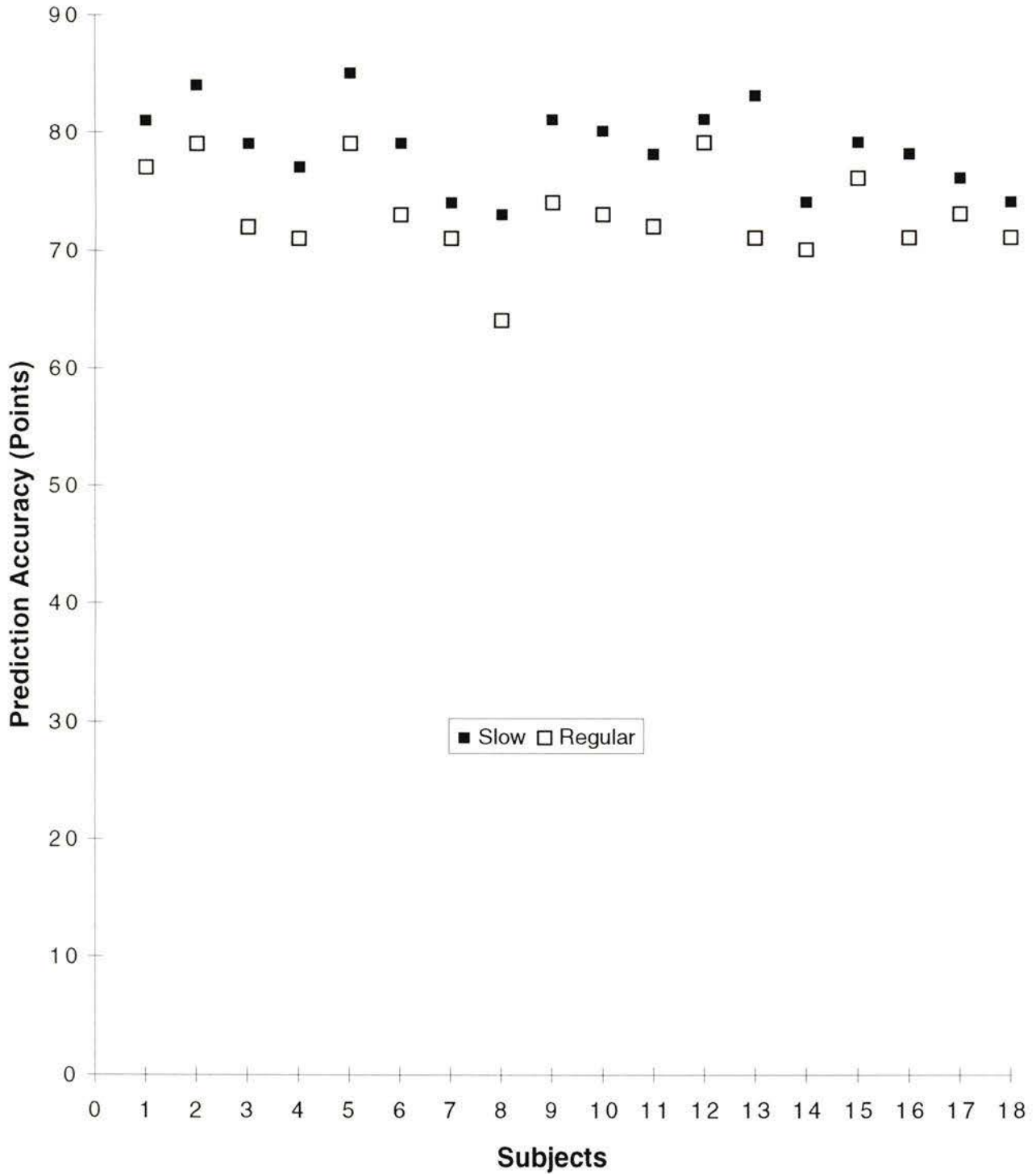


Figure 16. Total Prediction Accuracy for Advanced Players at Slow and Regular Speed

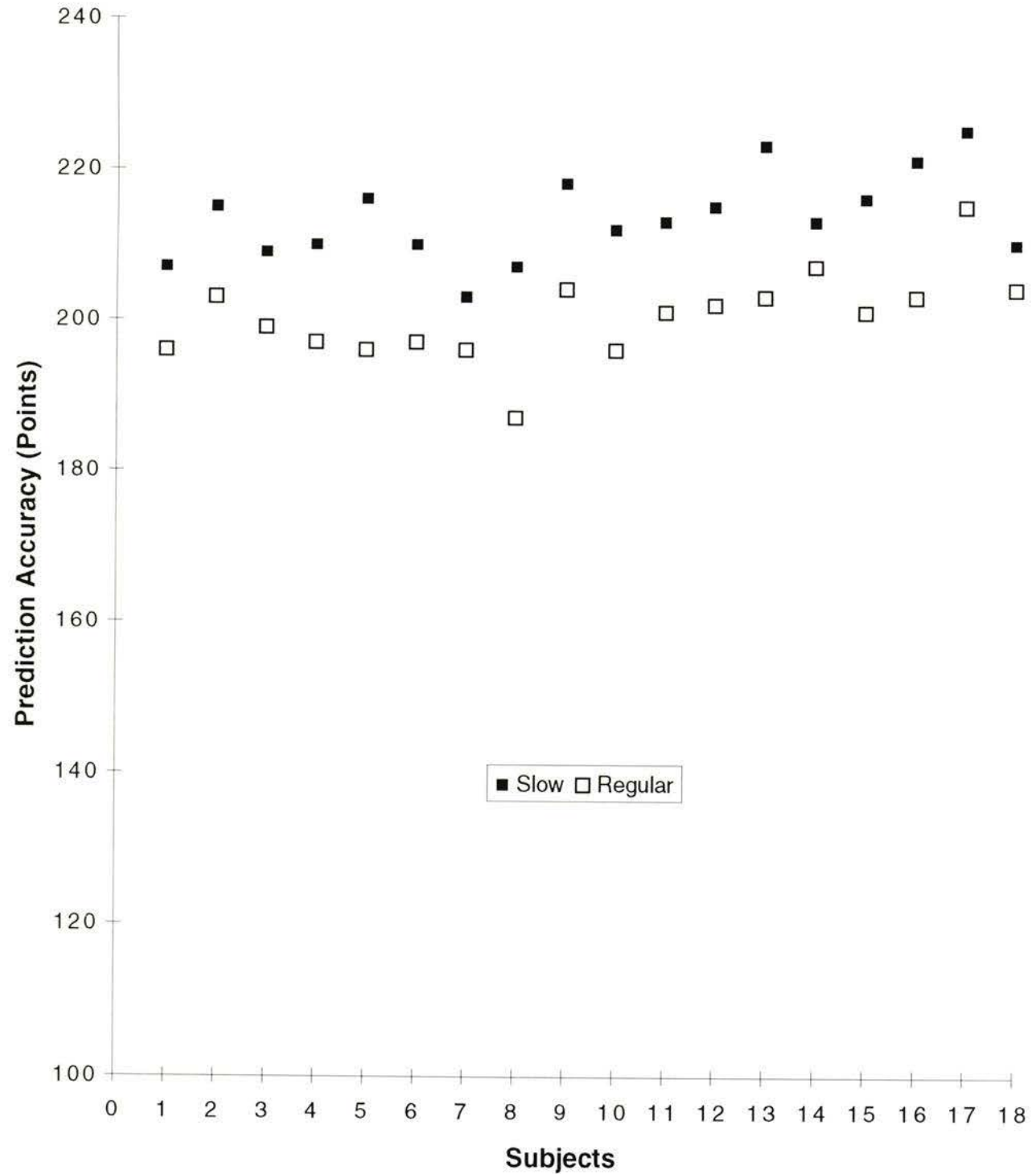


Table 7

Relationship Between Type, Depth, and Width of Serve
Prediction for Advanced Players at Slow and Regular Speed.

Condition	<u>n</u>	r
Advanced	36	
Type		.798*
Depth		.870*
Width		.770*
Total		.703*

Note. *Relationships are significant at $p < .05$.

The results of this study support the hypothesis that there would be a significant relationship between slow and regular play speed for advanced players prediction scores for serve type, depth, width and total. The relationship between slow and regular speed for each component was found to be strong. The extent of these relationships can be seen quite clearly in Table 7 and Figures 13, 14, 15, and 16. The results also revealed that the decrease in play speed had the effect of improving performance for all subjects and that improvement was in a uniform fashion.

4. *(Intermediate players only).*

There will be no significant relationship between slow and regular play speed prediction scores for intermediate tennis players in type, depth, width, and total serve.

Prediction accuracy for type, depth, width and total serve by each intermediate subject, at slow and regular speed, are presented in Figures 17, 18, 19, and 20.

Pearson's product moment coefficient of correlation revealed significant relationships between serve type prediction by intermediate players at slow and regular speed, $r(38) = .545$, $p < .05$; serve depth prediction by intermediate players at slow and regular speed, $r(38) = .601$, $p < .05$; serve width prediction by intermediate at slow and regular speed, $r(38) = .619$, $p < .05$; and total prediction accuracy $r(38) = .575$, $p < .05$. These results are presented in Table 8.

Figure 17. Prediction Accuracy for Serve Type at Slow and Regular Speed by Intermediate Players

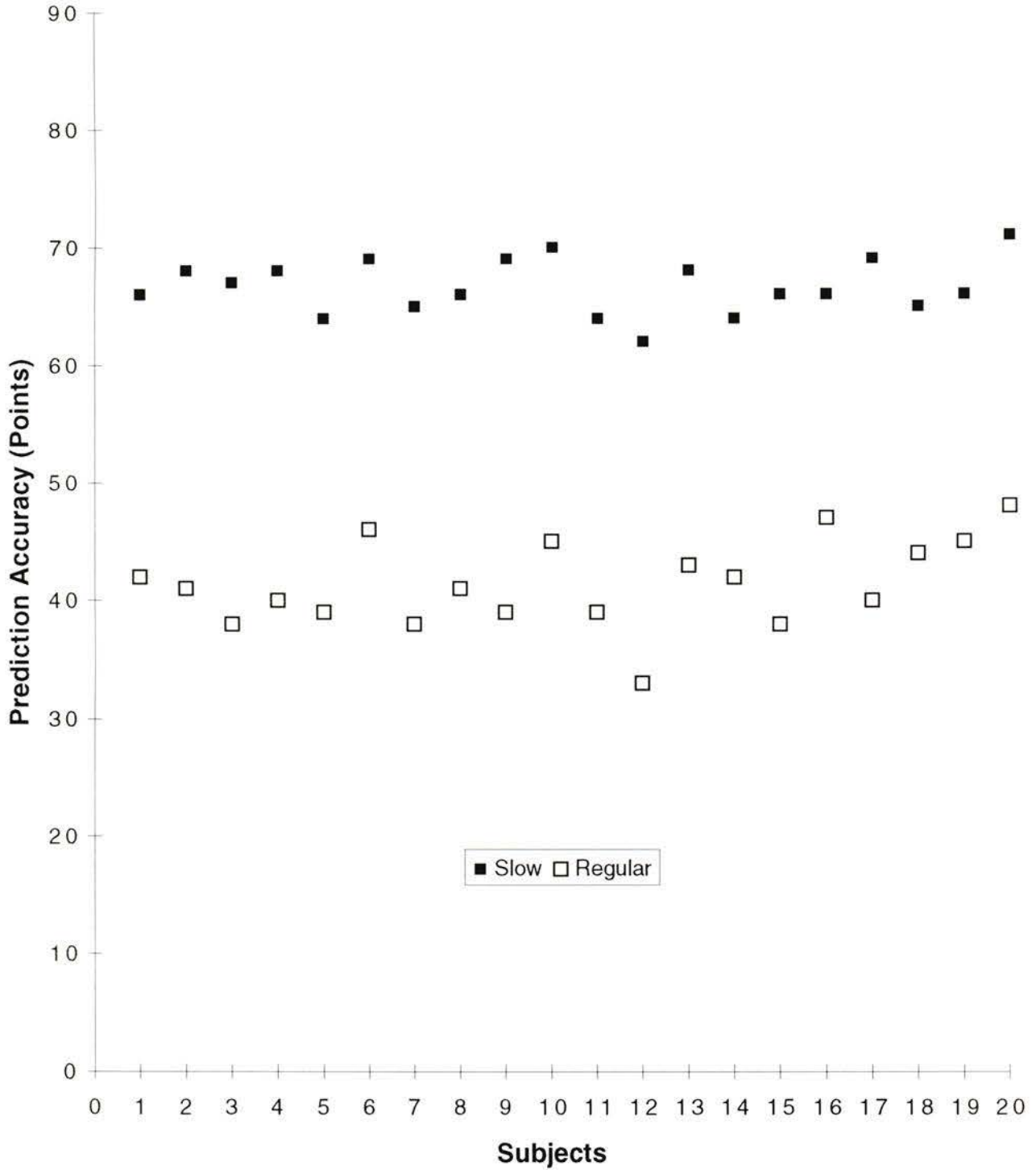


Figure 18. Prediction Accuracy for Serve Depth at Slow and Regular Speed by Intermediate Players

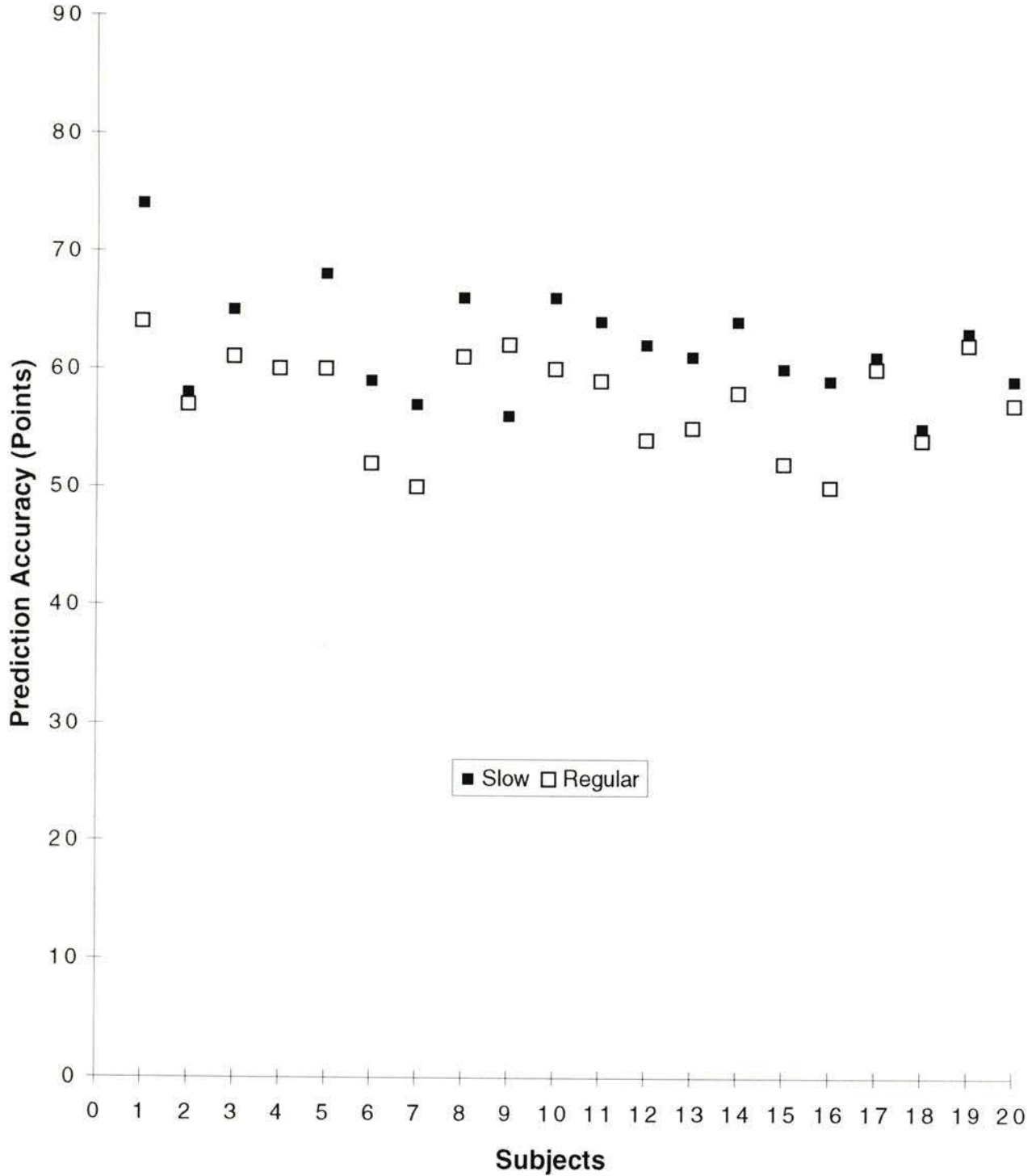


Figure 19. Prediction Accuracy for Serve Width at Slow and Regular Speed by Intermediate Players

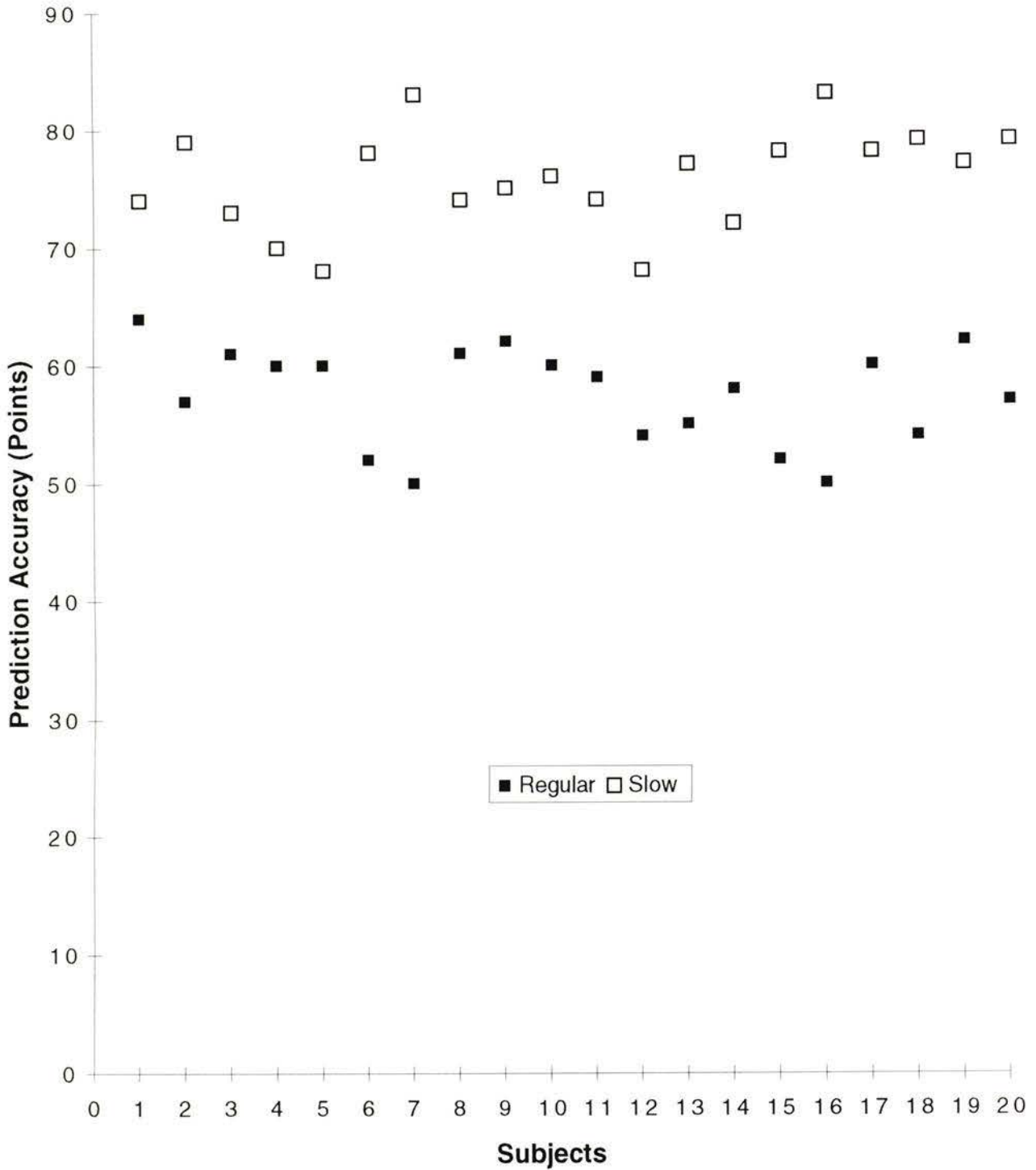


Figure 20. Total Prediction Accuracy for Intermediates at Slow and Regular Speed

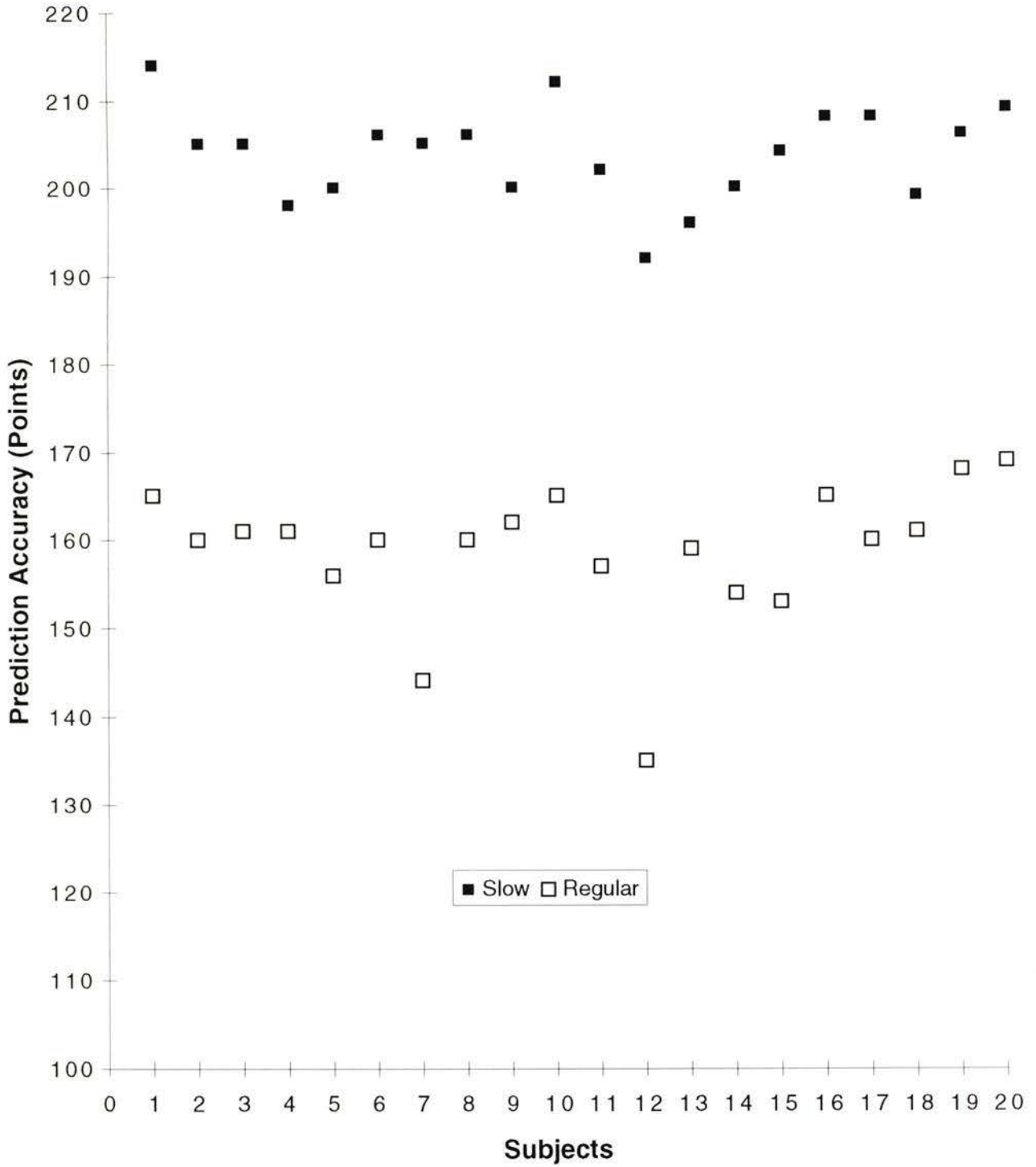


Table 8

Relationship Between Type, Depth, and Width of Serve
Prediction for Intermediate Players at Slow and Regular
Speed.

Condition	<u>n</u>	r
Intermediate	40	
Type		.545*
Depth		.601*
Width		.619*
Total		.597*

Note. *Correlations are significant at $p < .05$.

The results of this study revealed significant correlations between play speeds for the components of serve type, depth, width, and total predictions. These correlations, although strong, were not as high as those recorded for the advanced group. This would suggest more variability with regard to individual improvement.

The results of Experiment 1 would suggest that there was a difference in the skills of advanced and intermediate tennis players to accurately predict tennis serve type, depth, and width. The second part of this study attempted to answer the question as to whether serve identification practice, by means of video presentation, could aid the on-court performance of intermediate players.

CHAPTER IV

Research Methods, Results, and Discussion of Experiment II

Subjects

The subjects were three males and three females and they were all of an intermediate level. They all had participated in Experiment I

Procedure

Pre Treatment. Each subject returned, or attempted to return twenty tennis serves per session. The same server was used for all sessions and eighteen different serves were included in the twenty. The package of serves consisted of the following:

1. Three types of serve - flat, top spin, and sliced;
2. Three different landing positions - center line, middle of the receiving court, and inside tram line; and
3. Two differing depths - shallow and deep.

Note. All serves were into the right serve reception box and two of the serves were repeated, giving a total of twenty. (Twenty serves were used so as to permit a maximum accuracy prediction score of 100).

The return of each serve was evaluated in the following manner:

- (a). Five points were awarded for a return of serve which landed on the opponent's side of the court within the boundary lines;

- (b). Four points were awarded for a return of serve which either went over the net but landed outside the opponents court or went directly, without bouncing, into the net;
- (c). Three points were awarded for a return of serve which landed on the returnees side of the court;
- (d). Two points were awarded for a return of serve which did not go over the net nor land any where within the court; and
- (e). One point was awarded for moving in the direction of the serve.
- (f). No points were awarded for not hitting the ball or moving in the direction of the serve.

Feedback in the form of a point score was given immediately following each serve. The number of sessions per subject depended on when stability of performance was reached. Once a relatively stable baseline was achieved the subject moved to the intervention phase.

Intervention (Modified Changing-Criterion Design). Subjects were required to view, on a monitor, twenty serves selected from the original video tape of 108 serves. Immediately following occlusion each subject gave their prediction as to the type, depth, and landing position of each serve. As a means of evaluation, each correctly identified serve was again worth three points (one point for identifying each specific element). Therefore, for twenty serves it was possible to obtain a maximum of 60 points.

The film was played at five different speeds, beginning with the slowest speed first. To progress to the next speed a subject had to score 45 or more points, at least twice in succession, at each of the

played speeds. (A score of 45 represented a level of 75% accuracy in prediction. This was the mean level achieved by advanced players when viewing the original video tape in Experiment I).

The film speeds were 1/30, 1/20, 1/10, 1/5 and 1. The numbers represented the multiplying factors of the playback speed, where the normal playback speed was 1. Once a subject consistently scored 45 points at normal speed the treatment period was terminated for that subject. When viewing each serve, players were asked to stand three meters back from and facing the television monitor. They held a tennis racquet and as they watched each serve they were asked to not only orally respond to the serve but to physically complete an appropriate response.

The basic changing-criterion design begins with a baseline phase which in turn is followed by intervention. During the intervention phase a criterion is set for performance. If performance meets or passes the criterion, a consequence is provided. If performance consistently meets the criterion, the criterion is changed. When the new criterion is reached and performance stabilizes at this new level the criterion is again shifted.

The underlying rationale of the changing-criterion design is that the intervention is responsible for change and that performance would be expected to follow the shifts in the criterion. However, the design implemented in this study was a modified changing criterion design. It differed from the basic model in the following manner:

- The set level of performance remained constant and the conditions gradually changed.

- The measure of performance was confounded by the criterion itself. For example, should a subject score consistently high at a certain speed it cannot be assumed that they would not have achieved this performance at a faster play speed. However, a fall in a subjects performance followed by improvement during exposure to each successive criterion would suggest that the modified changing-criterion design was having an effect on behaviour.

Post Treatment. When all the requirements of the treatment sessions had been fulfilled each subject then participated in a number of post treatment trials. The procedure was identical to that of the pre treatment phase and continued until stability in performance was demonstrated. Stability levels of pre and post phases were then compared by assessing mean shift change, changes in level, changes in variability, and percentage of overlapping points.

Results and Discussion

The purpose of this portion of the study was to assess the effect that the video training intervention had on the ability of players to return tennis serves. The average serve return performance on each trial for each subject during the two phases of Experiment II is outlined in Table 9.

The mean shift, change in level, percentage of overlapping points, and change in variability from pre to post intervention for all subjects are shown in Table 10.

These results demonstrated that there was a clear intervention effect for all subjects. There was a positive mean shift for all six subjects from pre to post intervention; five subjects demonstrated a positive change in level, four subjects demonstrated an percentage overlap in points of less than 30 percent, and four subjects demonstrated a decrease in variability.

Serve prediction accuracy during intervention for each subject at five video play speeds are presented in Figures 21, 22, 23, 24, 25, and 26.

Subject 1. Serve return performance increased from a mean of 40.62 during pre intervention to 46.20 during post intervention (Figure 27). This represented a 6.16 point or 15.12 percent increase in serve return performance. This subject demonstrated an improvement both in performance and consistency of performance from pre to post intervention. The subject performed particularly well during the first trials of the pre intervention phase. These scores were similar to values recorded later during the post intervention stage. This would suggest that prior to the intervention this subject had the ability to perform at a level that would later be revealed during the post intervention phase. This would suggest that intervention served to develop consistency in performance rather than raise the performance of the subject to dramatic heights not previously attained. Therefore, for subject 1 it may have been the case that intervention more directly influenced consistency in performance rather than absolute improvement in performance.

Table 9

Means and Standard Deviations of Serve Return
Performance for Pre and Post Intervention Conditions in
Experiment II

Subject	Pre Intervention		Post Intervention	
	M	SD	M	SD
1	40.62	3.77	46.20	2.36
2	40.3	1.25	46.77	2.35
3	41.91	4.46	45.75	2.53
4	39.92	3.43	47.50	4.25
5	34.75	2.08	39.28	1.38
6	43.17	3.18	50.60	0.89

Note: Means are significantly different at $p < .05$

{ $t(10) = -3.07, p < .01$ }

Table 10
Mean Shift, Change in Level, Percentage of Overlapping Points, and Change in Variability from Pre to Post Intervention Conditions in Experiment II

Subject	Mean Shift	Change in Level	Change in Variability	Percentage of Overlapping Points
1	5.58	0.00	-1.41	56.25
2	6.03	1.20	1.10	7.70
3	3.84	1.03	-1.93	100.00
4	7.58	1.10	0.82	20.00
5	4.53	1.05	-0.70	29.00
6	7.43	1.02	-2.29	0.00

Figure 1. Serve Prediction Accuracy at Five Video Replay Speeds for Subject 1

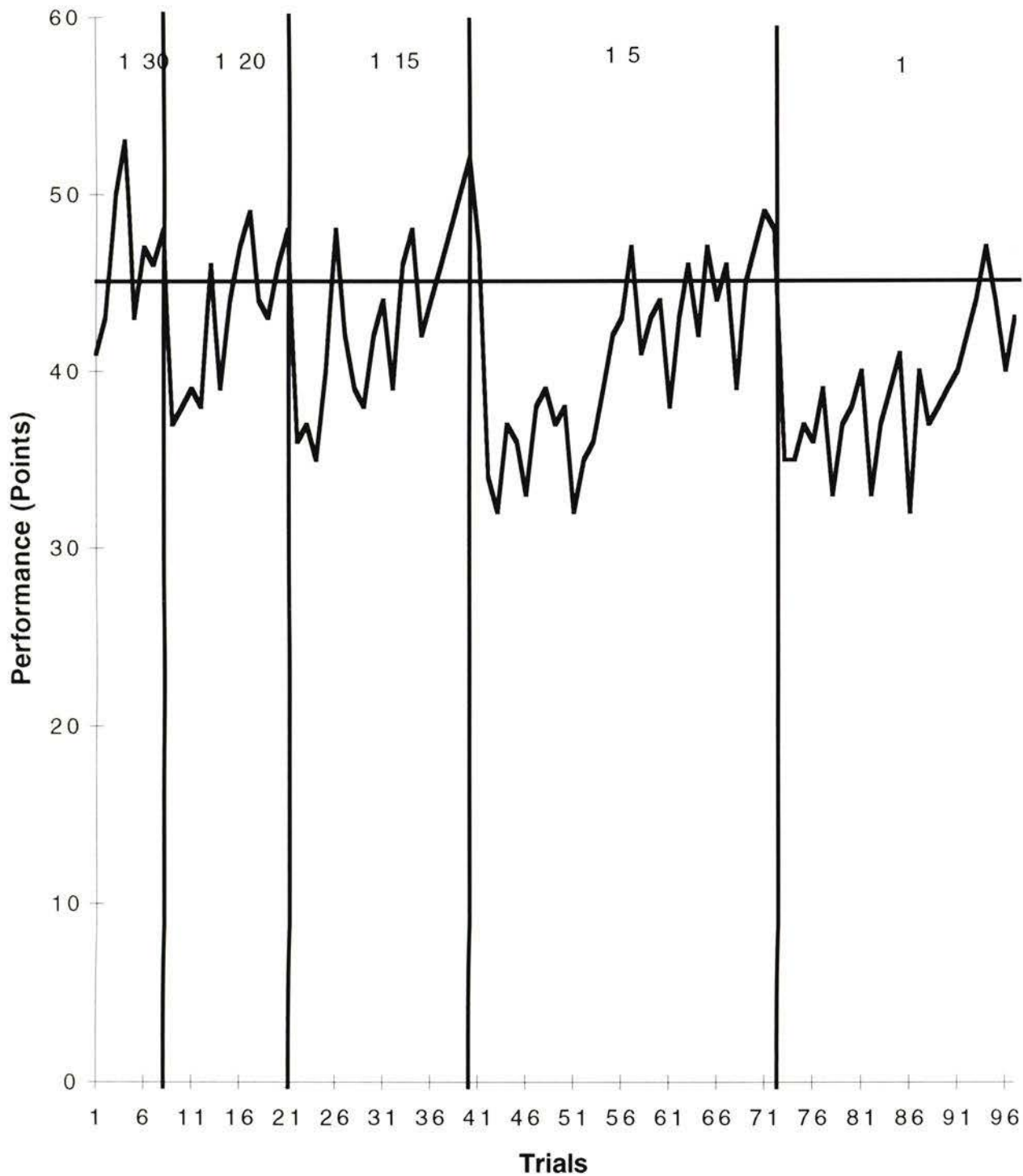


Figure 2. Serve Prediction Performance At Five Video Replay Speeds for Subject 2

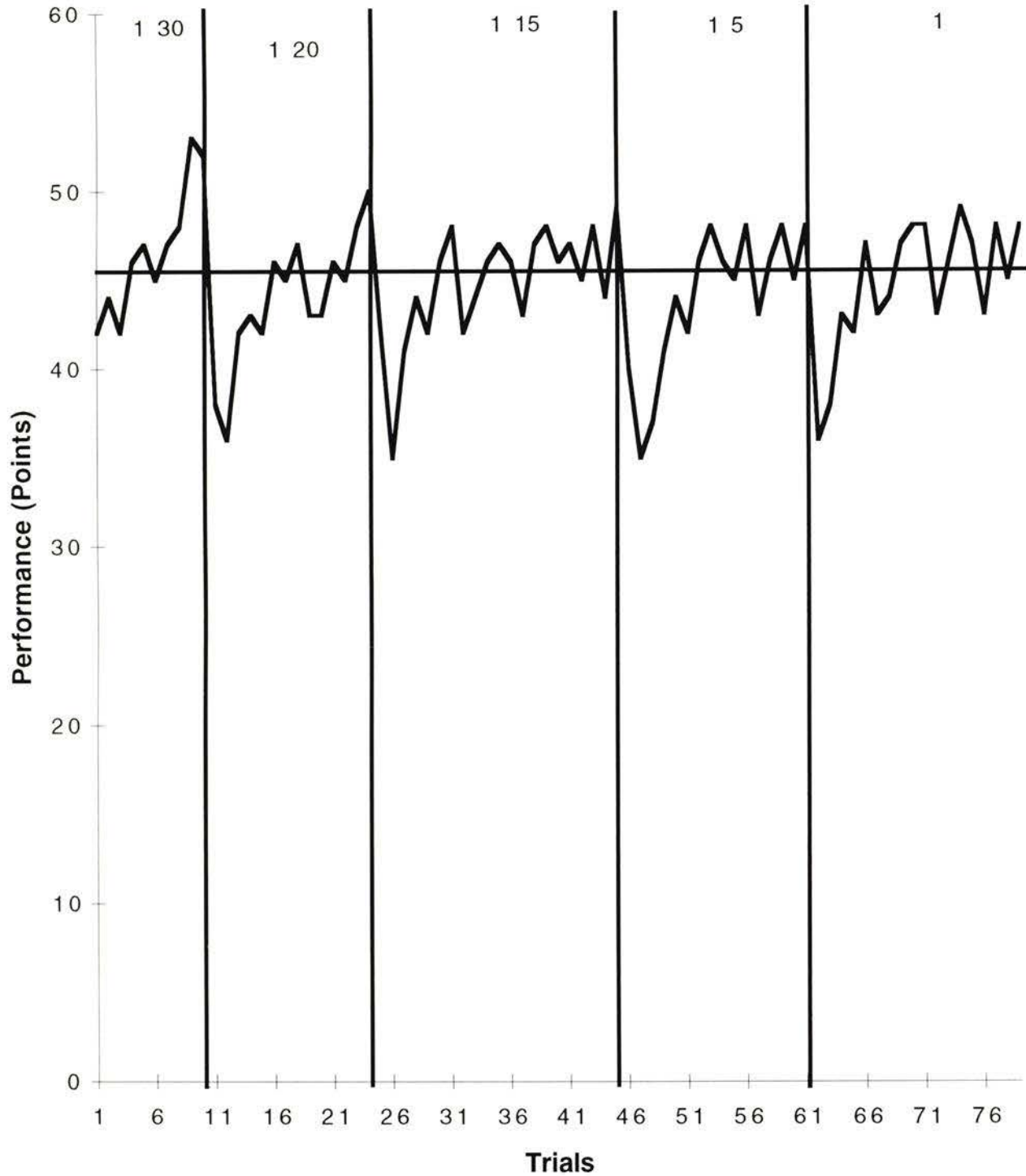


Figure 3. Serve Prediction Accuracy at Five Video Replay Speeds for Subject 3

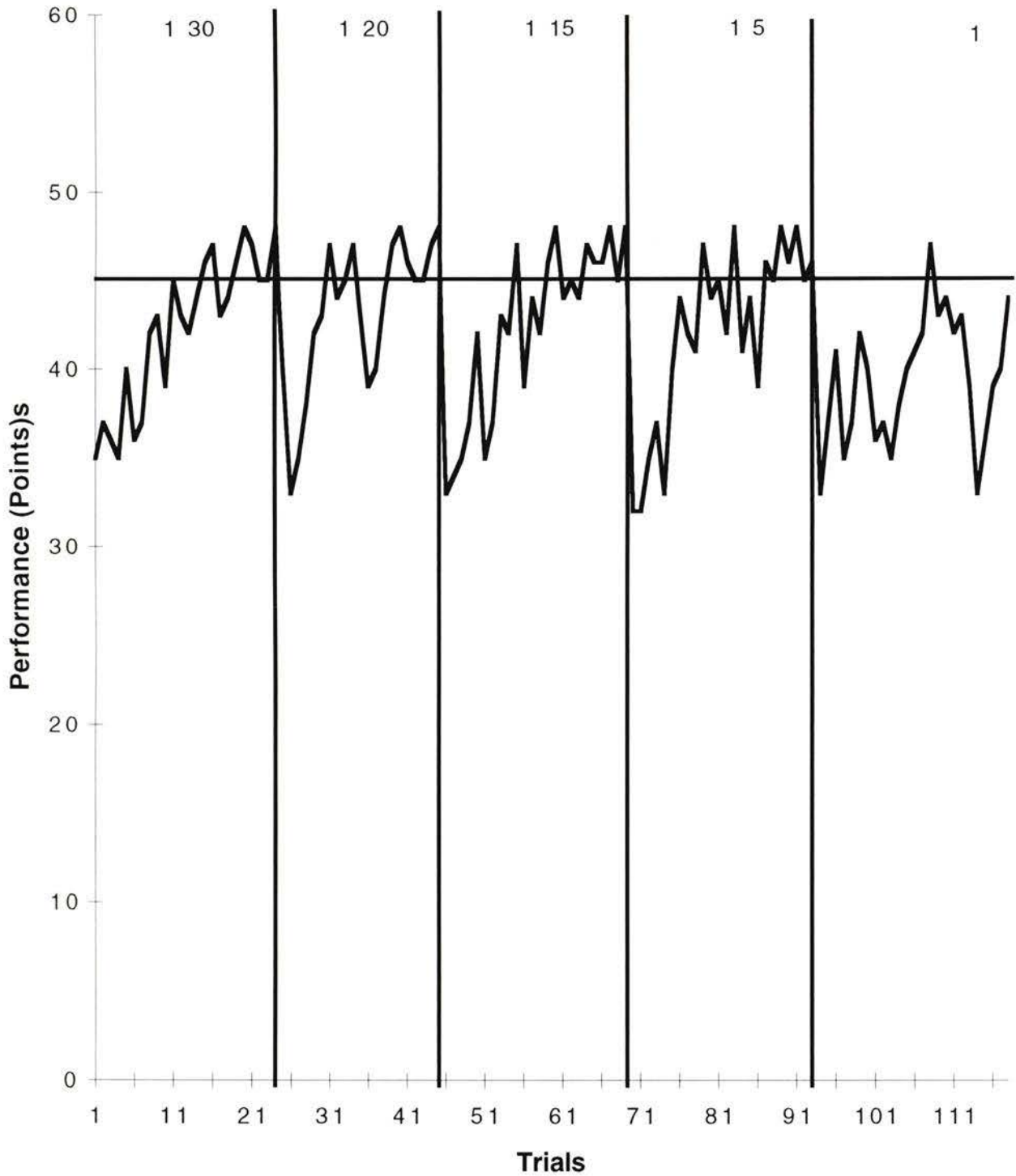


Figure 4. Serve Prediction Performance at Five Replay Speeds for Subject 4

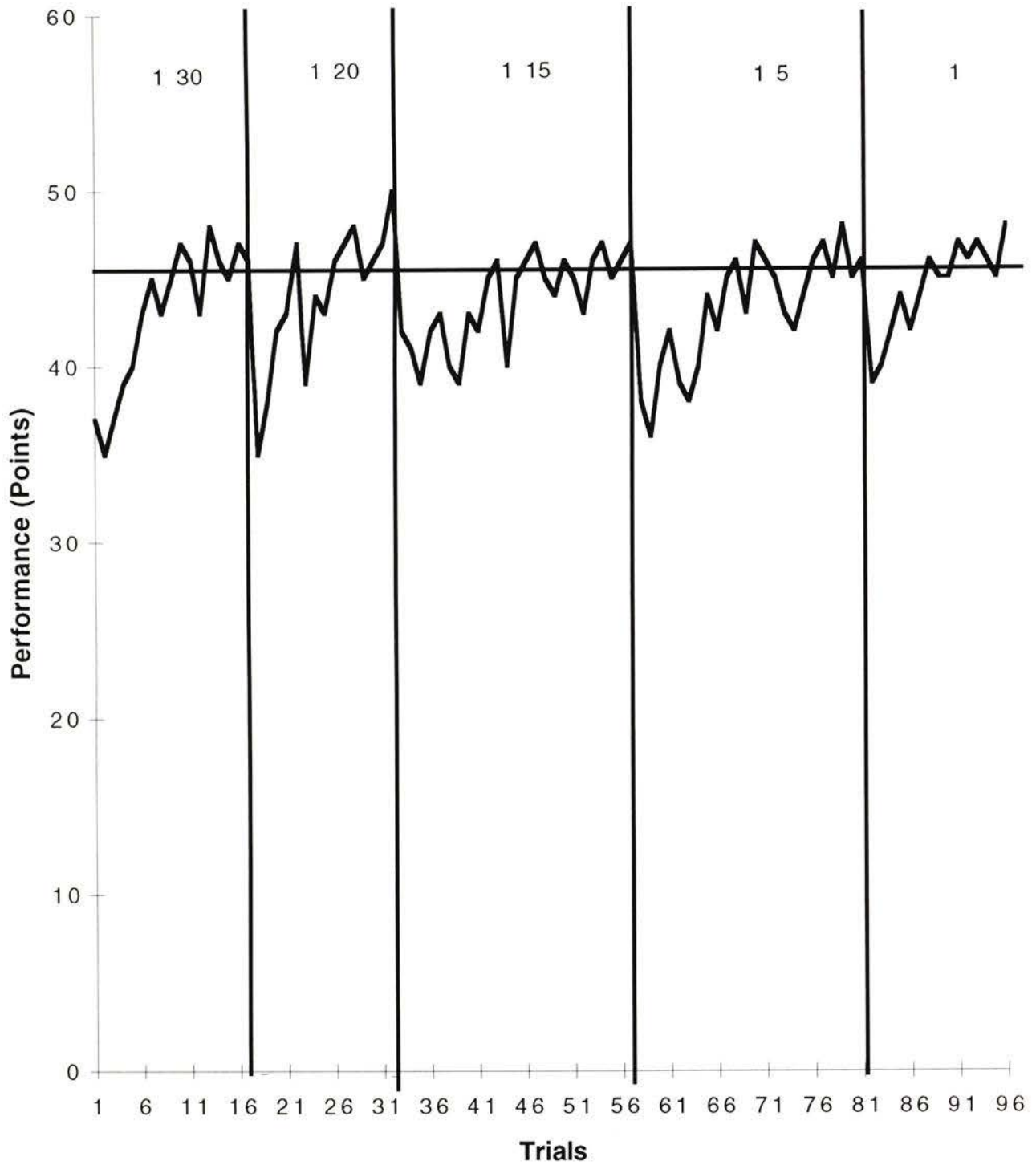


Figure 5. Serve Prediction Accuracy at Five Video Replay Speeds for Subject 5

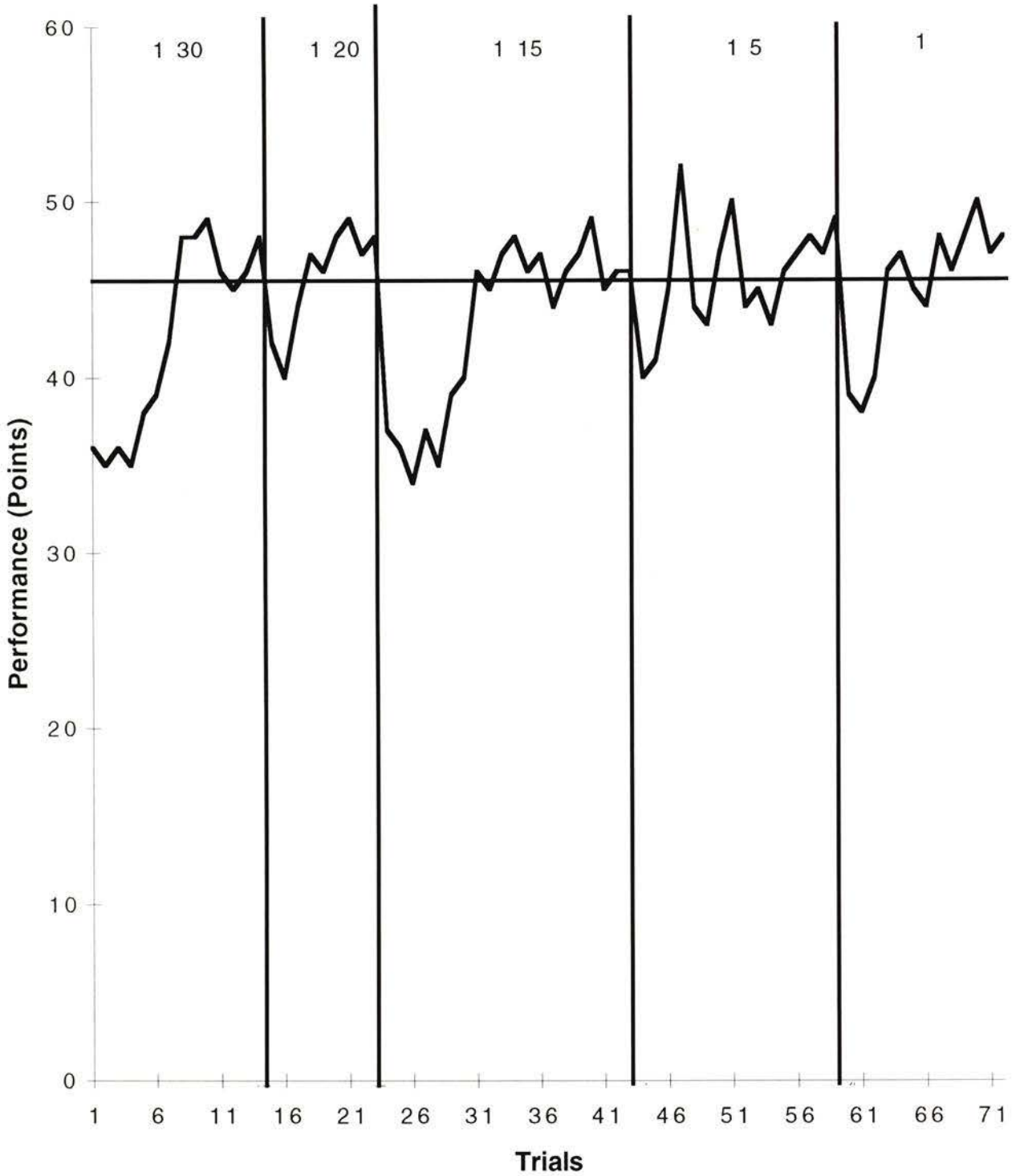


Figure 6. Serve Prediction Accuracy at Five Video Replay Speeds for Subject 6

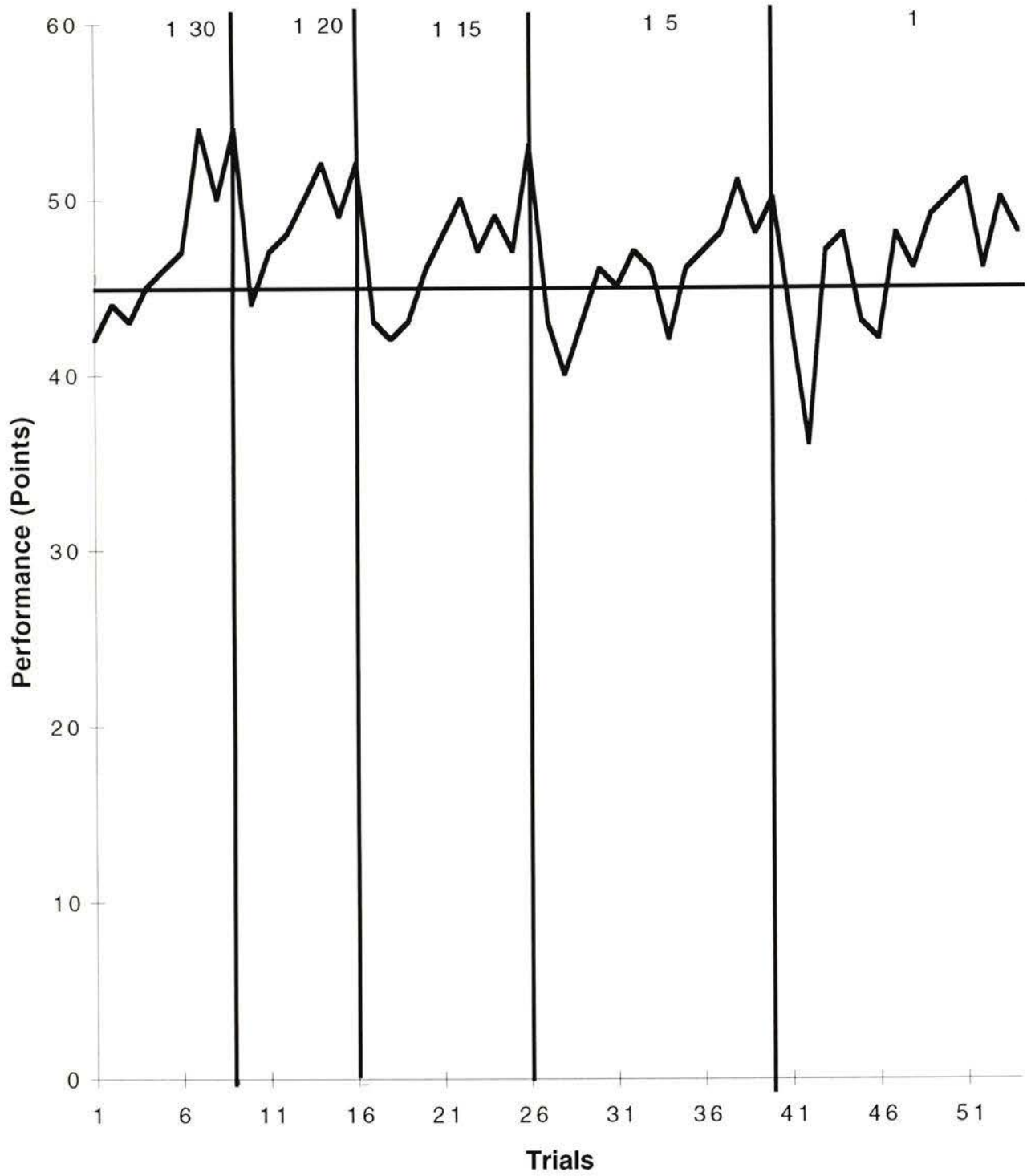
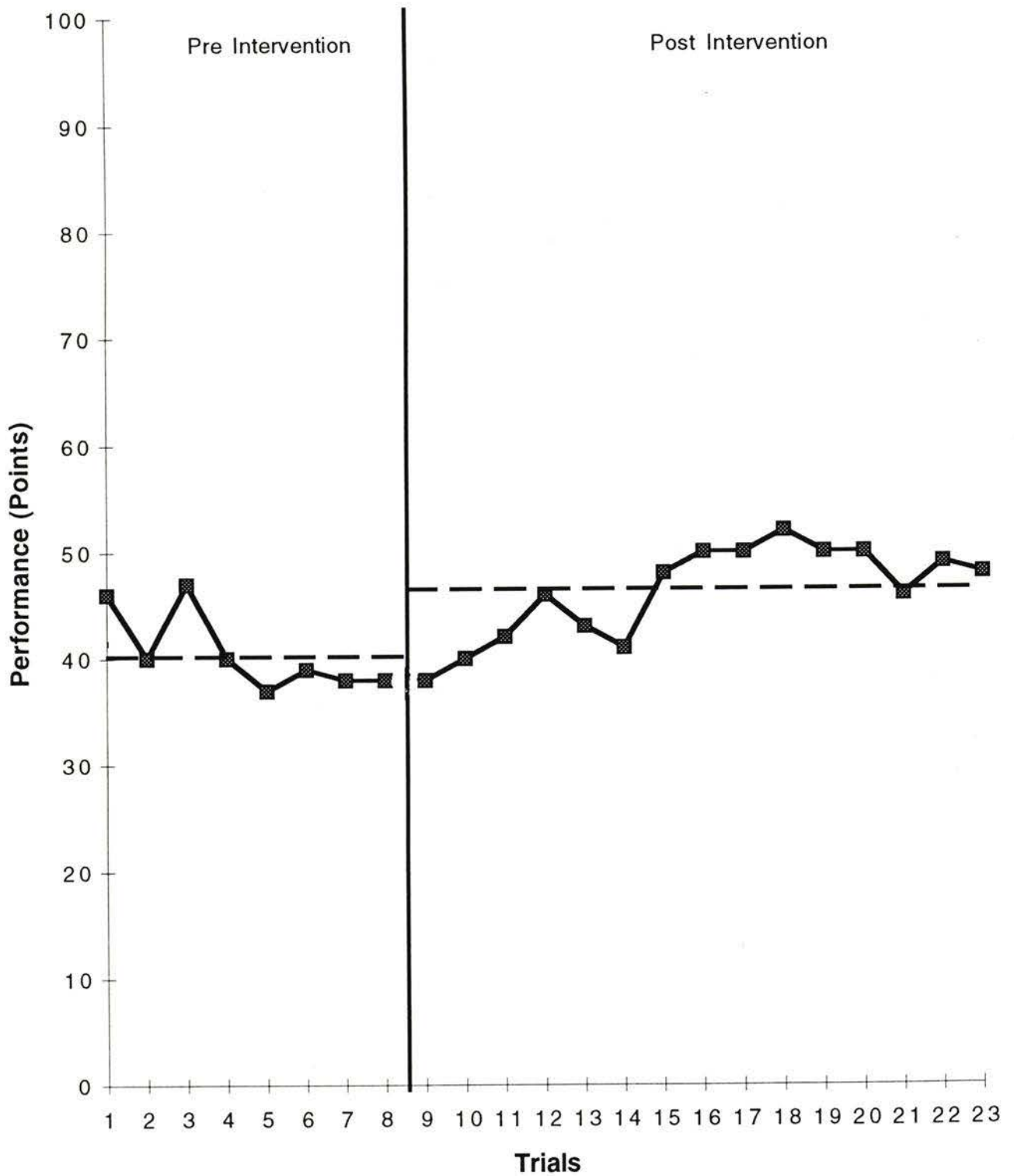


Figure 27. Serve Return Performance for Subject 1

Subject 2. Serve return performance increased from a mean of 40.30 during pre intervention to 46.77 during post intervention (Figure 28). This represented a 6.47 point or 16.05 percent increase in serve return performance. An examination of the standard deviations suggested that not only was intervention associated with an increase in serve-return performance, but also with a decrease in the level of post intervention consistency. This subject demonstrated a clear improvement in performance although not in consistency of performance from pre intervention to post intervention. Pre intervention was characterized by very stable, consistent performance. Post intervention was characterized by a clear improvement in performance and although performance lacked the consistency of pre intervention all scores recorded during the post intervention stage were equal to or greater than the highest value recorded during pre intervention. This would suggest that intervention may have had an effect on the absolute performance of this subject.

Subject 3. Serve return performance increased from a mean of 41.91 during pre intervention to 45.75 during post intervention (Figure 29). This represented a 3.84 or 9.16 percent increase in serve return performance. Standard deviations would suggest that although the increase in serve return performance from pre to post intervention was relatively small, consistency in performance during the post intervention phase increased quite markedly. As with Subject 1 this subject did particularly well at the beginning of the pre intervention stage before performance declined and leveled off. Post-intervention measures revealed higher mean performance and greater

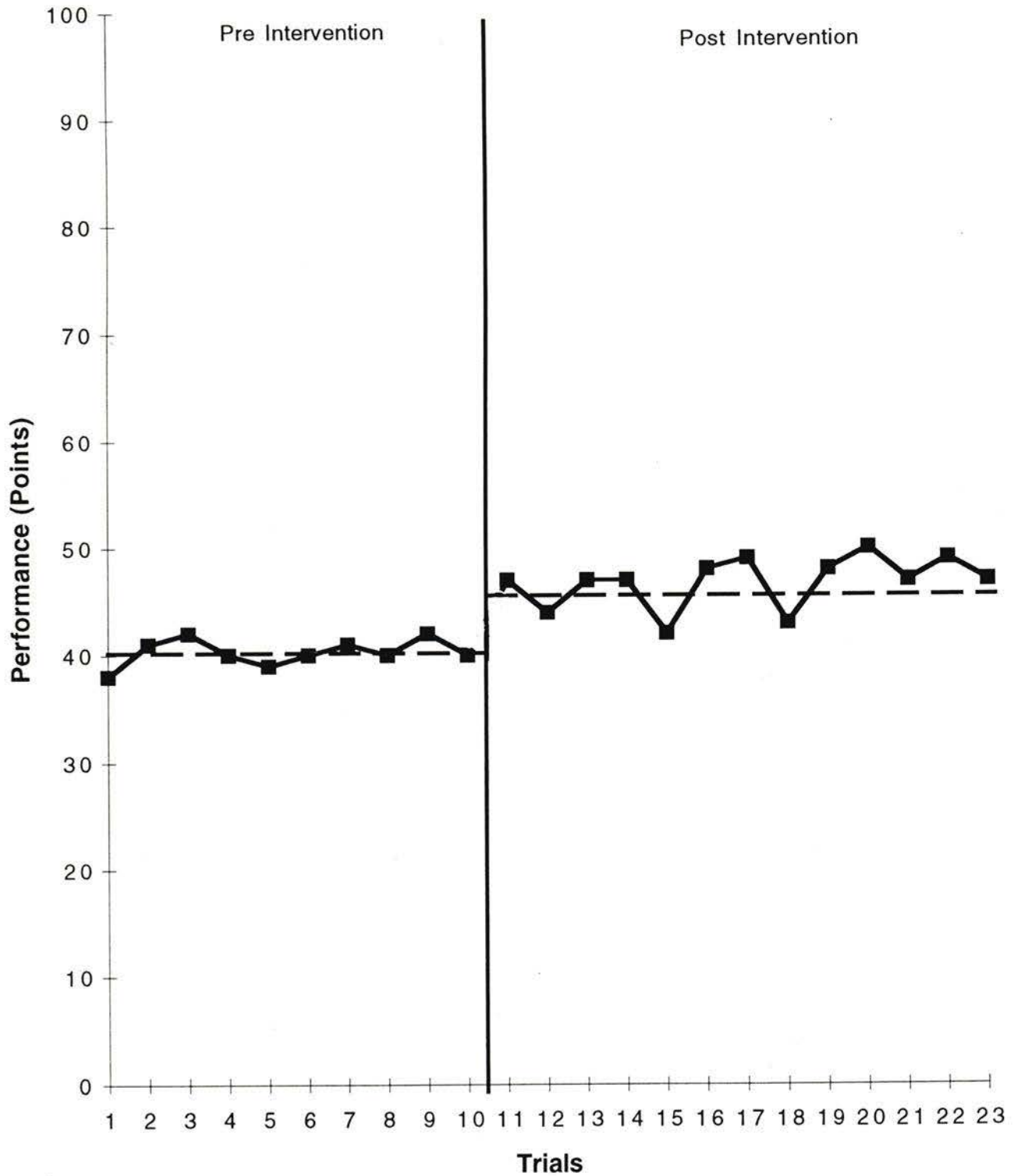
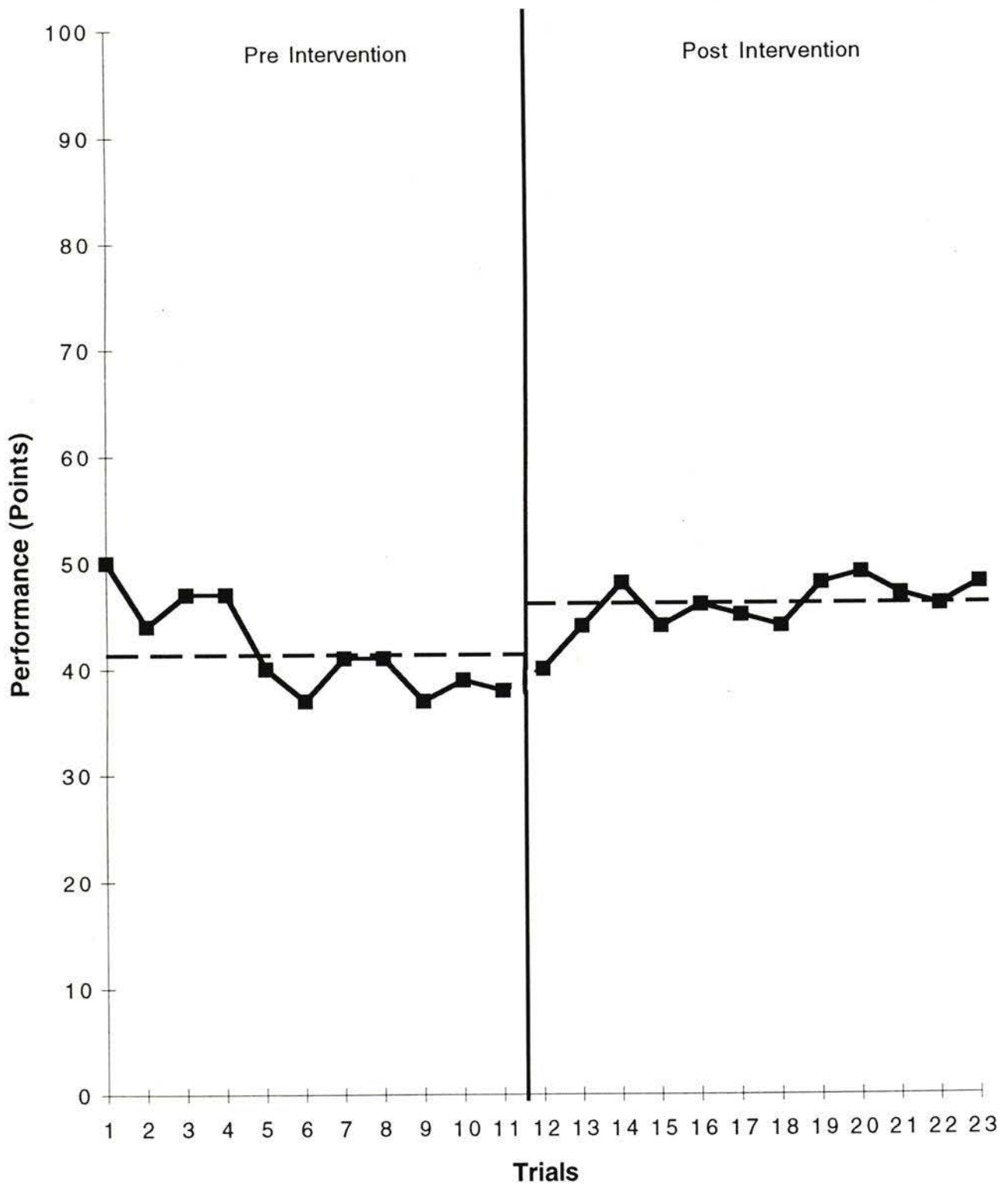
Figure 28. Serve Return Performance for Subject 2

Figure 29. Serve Return Performance for Subject 3

consistency in performance. It should also be noted that none of the scores recorded during the post intervention stage were equal to or greater than that value recorded in the first trial during pre intervention. This result suggests that the intervention did not have an effect on absolute performance but rather on consistency of performance. (It would also suggest that the high first value recorded by the subject occurred because the subject was excited, motivated, and keen with regard to experiment participation; a Hawthorne Effect.

Subject 4. Serve return performance increased from a mean of 39.92 during pre intervention to 47.50 during post intervention (Figure 30). This represented a 7.58 or 18.99 percent increase in serve return performance. This subject revealed a relatively slow but steady decline in performance across the pre intervention phase and a slow but steady improvement throughout the post intervention stage. Performance could not be described as ever being stable although the decline and later improvement could be described as being consistent. What is clear is that pre and post intervention performances are different. It would therefore seem possible to suggest that intervention did have an effect on post performance. This influence was evident throughout the post intervention stage.

Subject 5. Serve return performance increased from a mean of 34.75 during pre intervention to 39.28 during post intervention (Figure 31). This represented a 4.53 or 13.18 percent increase in serve return performance. Standard deviations would suggest that consistency in performance remained relatively high across both pre and post intervention phases.

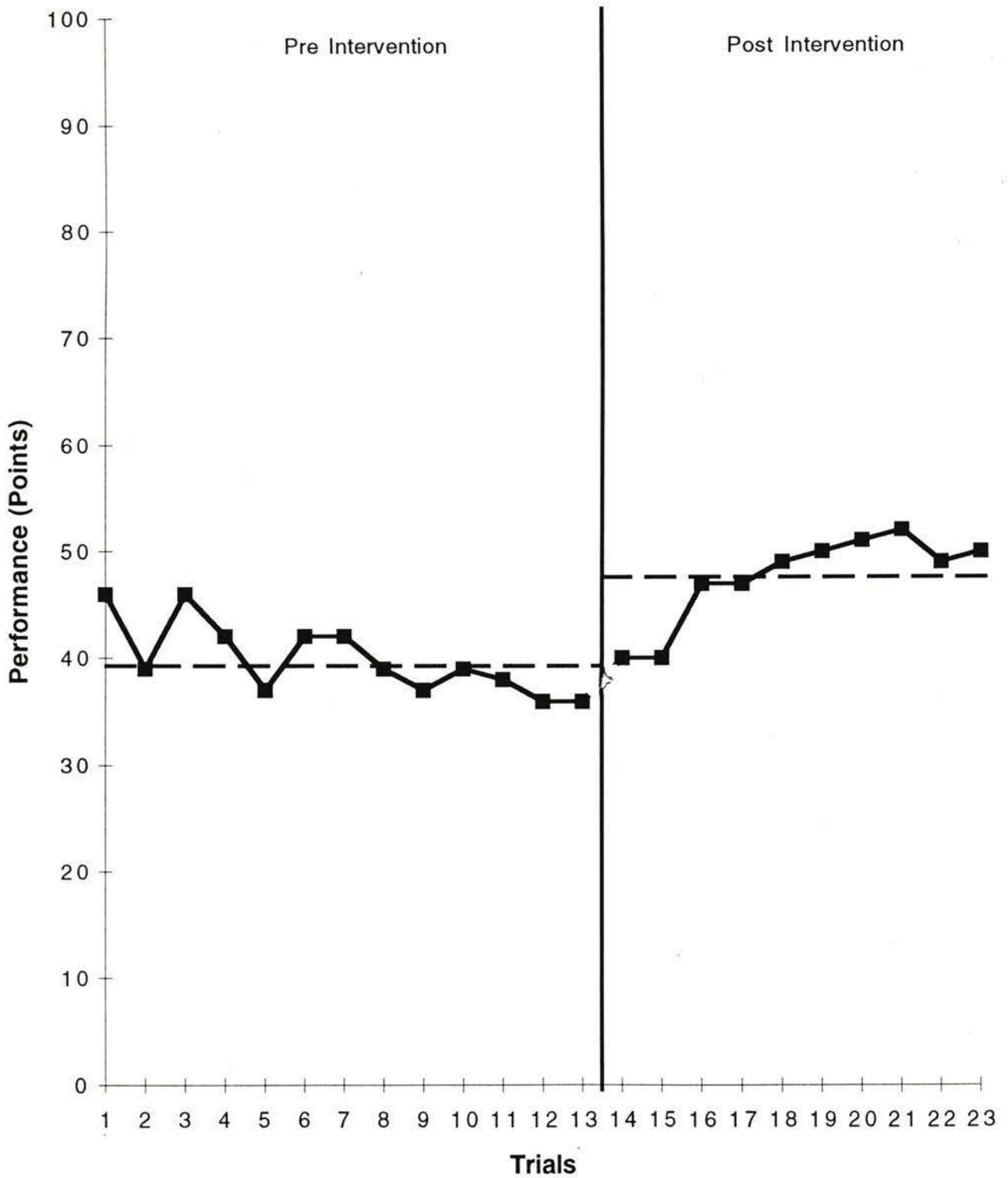
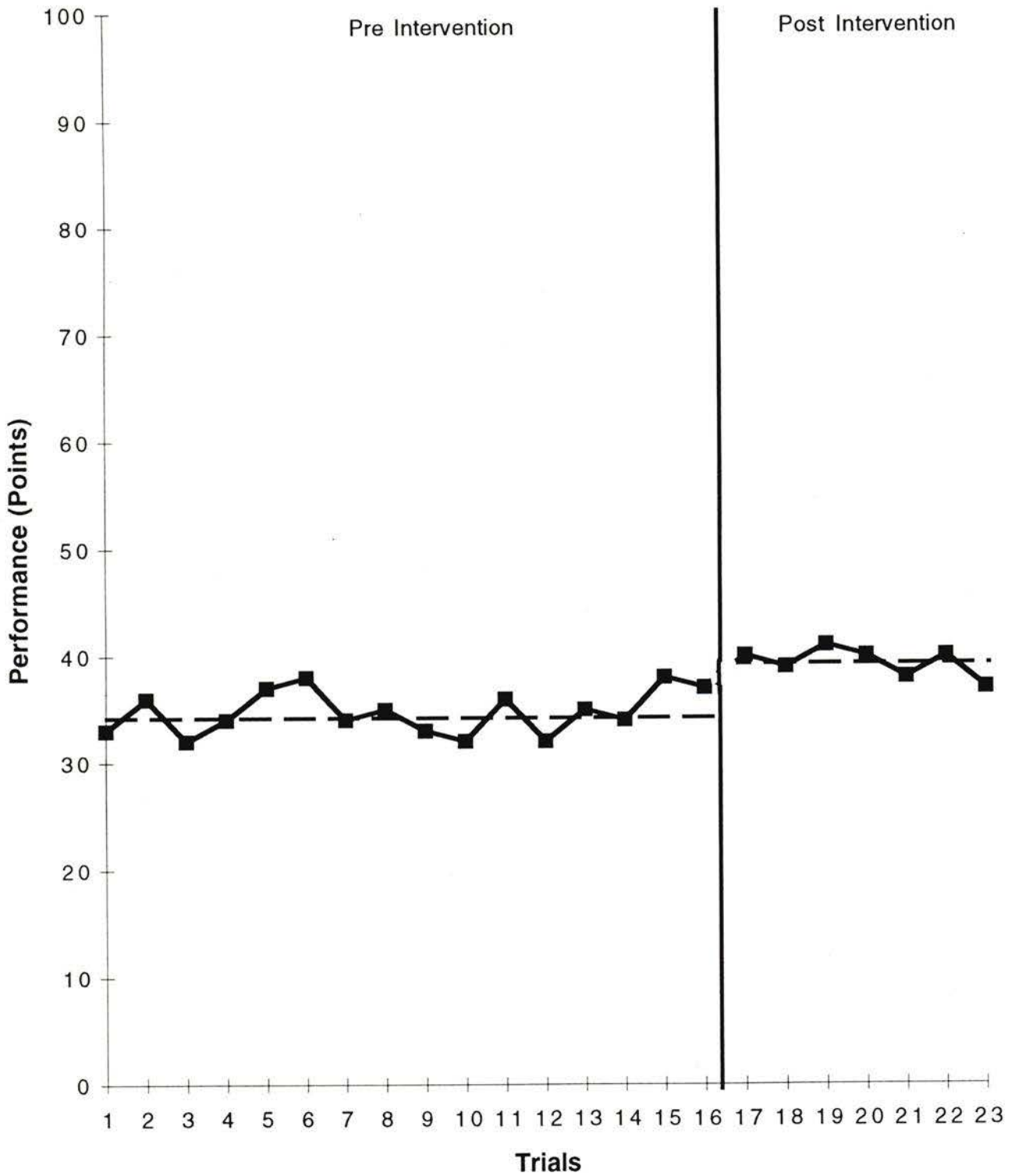
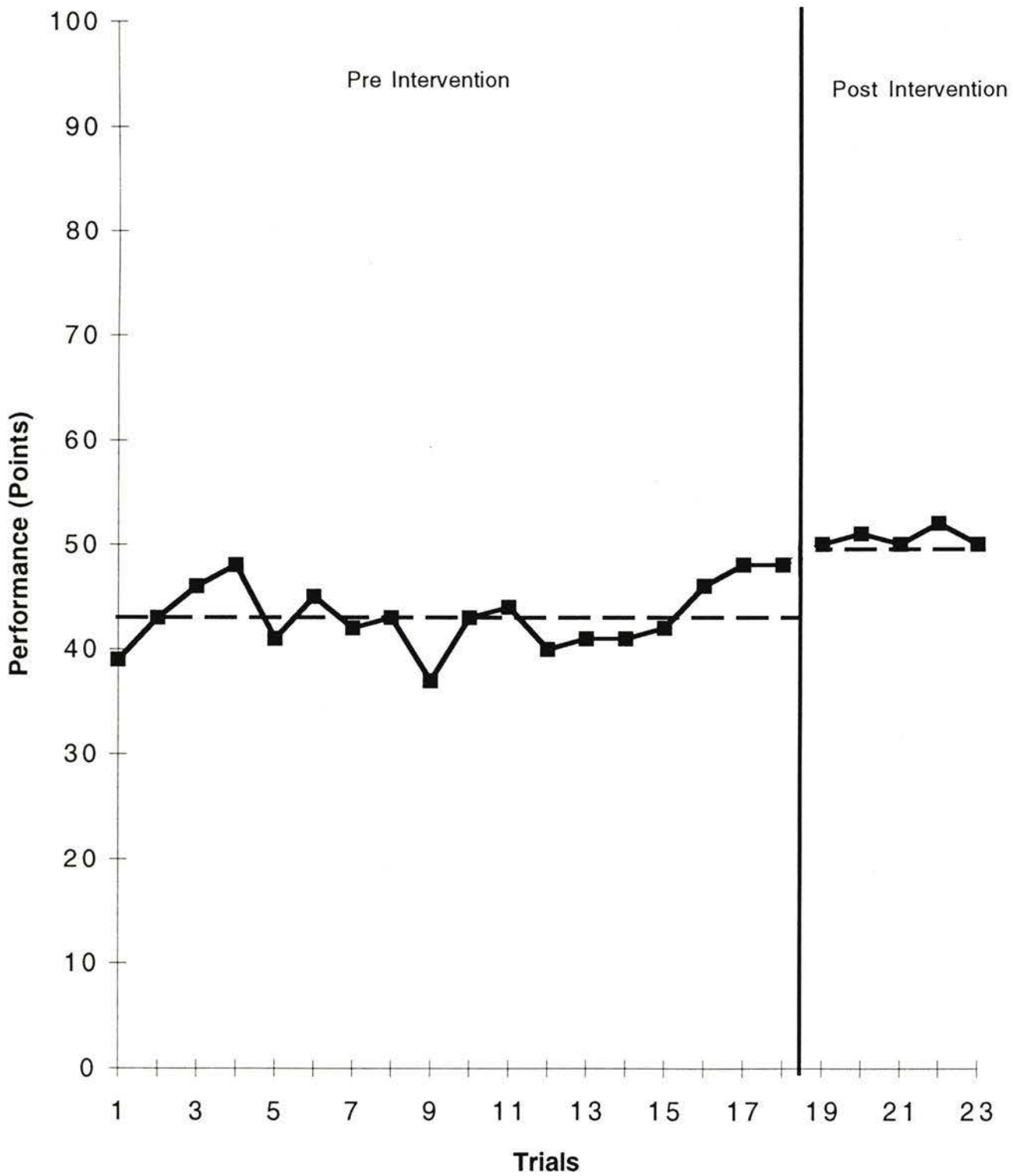
Figure 30. Serve Return Performance for Subject 4

Figure 31. Serve Return Performance for Subject 5

This subject revealed a small improvement in performance from the beginning of the study until its conclusion. However, it is difficult to see any clear effects for intervention. Although mean post performance is higher than that of pre intervention this difference is relatively small (4.5 %). A similar conclusion can be made with regard to consistency improvement. Therefore, with regard to this subject it is difficult to demonstrate that the subtle differences would not have occurred without intervention.

Subject 6. Serve return performance increased from a mean of 43.17 during pre intervention to 50.60 during post intervention (Figure 32). This represented a 7.02 or 16.57 percent increase in serve return performance. Standard deviations would suggest that consistency in performance also increased from pre to post baseline conditions. This subject remained at baseline for 18 of 23 trials. Baseline was characterized by an improvement in the consistency of performance. In the early stages of pre intervention this subject displayed relatively high but inconsistent performance. However as the subject became more accustomed to the testing procedure performance and consistency gradually improved. This pattern of improvement continued in the post intervention stage. As with Subject 5 it is difficult to conclude that intervention had a significant effect.

The results of this study support the hypothesis that there would be a significant difference between pre and post intervention scores with regard to on court serve return performance. The pre and post intervention phases followed a multiple baseline design which revealed that regardless of the pre intervention baseline

Figure 32. Serve Return Performance for Subject 6

length, or the length of intervention, all six subjects demonstrated an increase in serve return performance during the post intervention phase. This replication across all six subjects would suggest that the intervention did have a positive effect.

It should be noted that ball flight information which was available in pre and post sessions was not available during intervention. For all subject's,+ performance was shown to increase from pre to post intervention phases although not all increases in performance were accompanied by an increase in the consistency of performance.

CHAPTER V

Conclusions

The results of this study support previous findings reported in the literature (Abernethy, 1989; Day, 1980; Goulet, Bard & Fleury, 1989; Issacs and Finch, 1983; Starkes and Deakin, 1983; Starkes and Lindley, 1994) which indicate that advanced players are more accurate in predicting future outcomes than intermediate players. Experiment 1 revealed a significant difference in total accuracy prediction performance between advanced and intermediate level players at both slow and regular speeds for serve type-, depth-, and width-prediction at regular speed, and between advanced and for serve type prediction at slow speed. These results would suggest that at slow speed intermediate players, in comparison to advanced players, did not find serve depth and serve width prediction significantly more difficult to predict. These results are in part supported by Issacs and Finch (1983) who reported that width cues are the easiest cues to detect and by Abernethy (1989) who reported that advanced and intermediate groups found width (lateral prediction) easiest to detect. Thus one might expect intermediate players to find width to be easiest of the three components to predict. The relative ease of serve width detection may have resulted from the possibility that serve width advance cues often involve whole body movements which tend to make them difficult to disguise and relatively easy to detect.

Day (1980) reported a similar finding with regard to serve prediction in junior tennis players. This study revealed that lateral

cues were easiest to detect and that prediction accuracy was best in this area. Day also reported that depth cues were not as easy to detect as width cues and correspondingly prediction accuracy rates in this area were not as high as for those of width. The present study supports this finding. It should also be noted that both groups anecdotally reported that depth prediction was the most difficult. This difficulty however was somewhat masked by the fact that the serve receiver only had two choices (deep or shallow) and that a good guess had a high probability of being correct. Nevertheless, there are two possible reasons why depth prediction proved to be anecdotally the most difficult. It may have been that that depth was difficult to detect from video, and secondly, that ball flight, which was not present in this study, contains cues which aid in depth perception. This second suggestion has been put forward by Abernethy (1989) who argued that early flight cues help width prediction whereas later cues aid in depth prediction. This is supported by Lee (1980) who suggested that by making use of tau, a player can calculate when a ball will reach him. In this study since ball flight was occluded on racquet contact, tau was not available.

The greatest difference in performance between advanced and intermediate players occurred with regard to serve type prediction. Even at slow speed there was still a significant difference in performance between advanced and intermediate players and this suggests that superior prediction by advanced players resulted from their skill at using earlier information. Abernethy (1989) reported that there was no difference in the cue usage of badminton players. In other words, advanced and intermediate players employed similar

advance cues and similar search patterns. This in turn supports the contention that differences between advanced and intermediate players is a perceptual and information-processing speed problem. Goulet, Bard and Fleury (1989) lend support to this position by suggesting that in returning a tennis serve, information is often presented too rapidly for intermediate players to make a correct response. In other words the problem of serve type identification is not necessarily one of vision or scanpaths but rather one of information-processing speed.

There are a number of possibilities as to why advanced players did better with regard to serve prediction than intermediate players. Blundell (1984) reported that championship level and intermediate level tennis players were significantly faster in respect to reaction time and movement time than beginning players, with regard to standard reaction time tests. However, in cases where long previews of ball flight are permissible, reaction time probably has very little if any influence on performance. Furthermore, the notion of advanced players having some form of superior hardware has also been rejected in the literature (Cockerill and Callington, 1981; Starkes and Deakin, 1984). Goulet, Bard, and Fleury (1989) reported that when advanced and intermediate subjects were compared on non-task-specific abilities such as static acuity, depth perception, range of peripheral visual fields, reaction time, and coincident-anticipation ability, no significant differences emerge. Only when compared in domain specific abilities did advanced players show significant differences.

Goulet, Bard, and Fleury (1989) have reported that advanced players use information differently and need less information to identify the type of serve presented. Moreover, their decision time is shorter than that of intermediate players. The present study lends support to this finding. Results revealed that at regular play speed, advanced players had less difficulty in serve identification than intermediate players. At slow speed the disparity between the two groups was not as great..

To explain this finding, it has been suggested that advanced players are simply more proficient at decision-making than intermediate players. Serve prediction involves choices and according to Miller (1974) choice making involves the selection of an alternative response to a given state of affairs. Miller further pointed out that the classes of information that enter into decision-making include: (a) situation variables; (b) goal variables; (c) response alternatives; and (d) choice making policies or rules. For advanced tennis players specific advance cues often produce a regularized structure. This in turn leads to a specific number of responses resulting in the restriction in the number of response alternatives in addition to the limited processing of new ones. Consequently, among the many potential situation variables that might be sampled, relatively few remain operative, thus promoting proficiency in decision-making.

It has been shown by Samela and Fiorito (1979) that the success of motor acts is often determined by the efficient resolution of earlier problems such as detection and tracking. Advanced players tend to be more proficient at this task than

intermediate players. Information occurring later in ball flight would seem to be only confirmatory. Abernethy and Russell (1987) have suggested that this confirmatory nature of later cues is much more important to the intermediate than the advanced player. In this present study it may have been the case that intermediate players lacked confidence in decisions made on the bases of earlier, advance cues and that later cues, when available, served to confirm earlier decisions. For the advanced player however, these later confirmatory cues are not required. The cues are therefore redundant and not utilized by the advanced player. Ripoll (1991) supported this position and suggests that a feeling of uncertainty often prohibits the intermediate from planning ahead. However, Carlton (1981) argued that later cues can play a role over and above that of confirmation. He suggested that the time needed to process visual information and to use this information may be faster than previous estimates. It is argued that response adjustments can take place with relatively short latencies and that ongoing responses may be closed through closed-loop feedback mechanisms. Carlton (1991) further suggested that corrections that require additional activation of an already active muscle occur more quickly than muscles requiring deactivation of an active muscle and activation of a new muscle. This supports the contention that later cue information may play a role greater than that of mere confirmation.

There has also been criticism of the type of testing procedure employed in this present study. Jones and Miles (1978) argued that one cannot be sure that a person's response to a film would be the same as their response to the real thing. They pointed out that film

and video play, in addition to lacking time of ball arrival, does not contain correct depth cues, nor require response execution. Mestre and Pailhous (1992) supported this position and further point out that in the playing environment ball flight might be important for continual adjustment of response. This suggestion is in turn supported by Carlton (1991).

In response to these criticisms a number of researchers, including the present one, have attempted to study anticipation and perception in the sporting environment, with the intention of determining whether anticipatory skills can be learned (Burroughs, 1984; Christina, et al., 1990; Day, 1980; Haskins, 1965; Londeree, 1964; Starkes & Lindley, 1994). Christina, et al. reported that video training was an effective method for improving response selection accuracy in football linebackers and that this could be achieved without sacrificing response selection speed. In a similar study Starkes and Lindley (1994) reported that structured video training can be a useful supplement to regular on court training. They reported that video training can be effective in increasing the accuracy of decisions made by players in addition to reducing decision time. However, Day (1980) reported that video training for tennis had not resulted in any significant improvement in on court performance. Day suggested that this may have resulted from his use of advanced players and that on court improvement, as a result of video training, may be more clearly seen with intermediate players.

The present study examined the influence of video training on intermediate tennis players with assessment occurring on the court. The results of the study do lend some support to the suggestion that

video training may be a beneficial supplement to on court training. However, although a significant pre and post intervention effect was reported, as with the Starkes and Lindley (1991) study the effect of video training is still inconclusive. For a number of subjects, this present study did seem to increase the accuracy of on court decisions and from this one may infer that there was a corresponding decrease in decision-making time. When asked anecdotally about changes in performance, a number of subjects reported that during the post intervention trials they felt more confident about their ability to identify and return serves. This growth in confidence may have resulted from the development of a more constant, structured perceptual environment which in turn may have produced a decrease in redundant searches and processing. This development of a more structured perceptual environment may be one of the benefits of video training transfer.

The results of this study revealed that there is a significant difference between advanced and intermediate players for prediction accuracy regardless of play speed. However, this difference in performance is somewhat smaller at slow speed which suggests that the difference in performance between advanced and intermediate players' may result from information-processing differences rather than visual search differences.

In the second part of the study, there is guarded support for the contention that video training can be a supplement to on court training for serve return. Significant differences between pre and post on court performances would seem to suggest that video training, in some part, transfers to the actual task. Thus, while video

training should not replace physical training, it may be a beneficial addition or temporary substitute to on court practice.

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APPENDIX A
Data Collection Sheet

Totals _____
 Speed _____
 Subject # _____ Expert _____
 Slow 1st _____ Date _____

Serve#	Sequence
1	S - D - M
2	F - M - W
3	TS-D - T
4	S - M - M
5	F - D - W
6	TS-M - T
7	S - D - W
8	F - M- T
9	TS-D - M
10	S - M - W
11	F - D - T
12	TS - M - M
13	S - D - T
14	F - M - M
15	TS-D - W
16	S - M - T
17	F - D - M
18	TS- M - W

Serve#	Sequence
1 9	S - D - M
2 0	F - M - W
2 1	TS-D - T
2 2	S - M - M
2 3	F - D - W
2 4	TS-M - T
2 5	S - D - W
2 6	F - M- T
2 7	TS-D - M
2 8	S - M - W
2 9	F - D - T
3 0	TS - M - M
3 1	S - D - T
3 2	F - M - M
3 3	TS-D - W
3 4	S - M - T
3 5	F - D - M
3 6	TS- M - W

Serve#	Sequence
37	S - D - M
38	F - M - W
39	TS-D - T
40	S - M - M
41	F - D - W
42	TS-M - T
43	S - D - W
44	F - M- T
45	TS-D - M
46	S - M - W
47	F - D - T
48	TS - M - M
49	S - D - T
50	F - M - M
51	TS-D - W
52	S - M - T
53	F - D - M
54	TS- M - W

Serve#	Sequence
55	S - D - M
56	F - M - W
57	TS-D - T
58	S - M - M
59	F - D - W
60	TS-M - T
61	S - D - W
62	F - M- T
63	TS-D - M
64	S - M - W
65	F - D - T
66	TS - M - M
67	S - D - T
68	F - M - M
69	TS-D - W
70	S - M - T
71	F - D - M
72	TS- M - W

Serve#	Sequence
73	S - D - M
74	F - M - W
75	TS-D - T
76	S - M - M
77	F - D - W
78	TS-M - T
79	S - D - W
80	F - M- T
81	TS-D - M
82	S - M - W
83	F - D - T
84	TS - M - M
85	S - D - T
86	F - M - M
97	TS-D - W
88	S - M - T
89	F - D - M
90	TS- M - W

APPENDIX B
Consent Form



INFORMED CONSENT

I understand that the purpose of this study is to examine anticipation ability with regard to the return of serve in the game of tennis.

I confirm that my participation as a subject is entirely voluntary. No coercion of any kind has been used to obtain my cooperation.

I understand that I may withdraw my consent and terminate my participation at anytime during the study.

I understand that all results will remain confidential, and that if requested the data will be destroyed after analysis.

Signature: _____

Date: _____

VITA

Surname: Scott

Given Names: David

Place of Birth: Londonderry Date of Birth: Nov. 17, 1963
Northern Ireland

Educational Institutes Attended:

University of Ulster	1982 to 1986
University of Victoria	1986 to 1995

Degrees, Diploma, Etc. Awarded:

B.A. (Hons.)	1986	University of Ulster
P.G.C.E. (Dist.)	1986	University of Ulster
M.A.	1988	University of Victoria
M.A.	1991	University of Victoria

Honours and Awards:

Dean's Graduate Fellowship, 1988
University of Victoria Graduate Fellowship, 1989 - 1991

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**ANTICIPATION ABILITY IN EXPERT AND NON EXPERT
TENNIS PLAYERS: IT'S OBSERVATION AND
DEVELOPMENT**

Author:



(Signature)

DAVID SCOTT

(Name in Block Letters)

MARCH 17, 1996

(Date)



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