CHARACTERISTICS OF THOUGHT PROCESSES AND KNOWLEDGE STRUCTURES OF NOVICE TENNIS PLAYERS

by

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ABSTRACT

Performers of physical skills develop knowledge structures in which the content, structure and process of special skills as well as context information are represented (Allard & Burnett, 1985; Gardner, 1985; Vickers, 1986). In the teaching of sports and physical education we deal with complexly organized knowledge structures and mental operations and changes occur as one (students, athletes, teachers and coaches) progresses from the novice to expert levels. The differences between the knowledge representation of experts and novices were documented in many areas, such as chess (Chase & Simon, 1973), physics (Chi, Feltovich & Glaser, 1981), mathematics teaching (Leinhardt & Smith, 1985) and gymnastics (Vickers, 1986).

The basic purpose of this study was, for pedagogical reasons, to better understand the development of the novice performers' knowledge structure by exploring their thought processes in action. The focus was upon novice tennis players during the game situation. Four novice level volunteer students from a physical education tennis performance class were the subjects of this study. A multiple case study method utilizing both qualitative and quantitative data was employed. The qualitative method and procedure of stimulated recall (Grimmett, 1982; Housner & Griffey, 1985; Peterson, 1982; Tuckwell, 1980) was used to obtain verbal reports disclosing the novices' thought processes when reviewing the video tape segments of their play. Quantitative performance data using the CompuTennis scoring system were analyzed in order to verify the accuracy of the subject's comments during the analysis of their interview transcriptions. Moreover, field notes and two questionnaires completed

multiple source data base in order to permit the analysis of a subject in all dimensions.

A description of what the players thought and felt during the interview in relation to their tennis performance was presented and the players' thought processes and knowledge structures were analyzed and interpreted in relation to the complex internal and external cues reported in particular game situations.

Diagrammatical summary of each case was presented as a representation of a player's thought processes and knowledge structures. As well, a novice player's thought processes and knowledge structures were discussed with a comparative view in relation to selected stage theories (Anderson,1982; Dreyfus & Dreyfus, 1986; Jewett & Mullan, 1977).

The present multiple cases revealed common themes across the cases of the novices as well as distinct individual differences in terms of the breadth, depth, organization and accessibility of the knowledges, working memory capacity and information processing efficiency (Kyllonen & Christal, 1989). Moreover, from the results of the study, developmental processes of compilation, composition and proceduralization of knowledges of action (Anderson,1982) in the tennis game situation were discussed. Finally, the implications were discussed for the designs of instruction of skill performance.

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1.STATEMENT OF THE PROBLEM

1.1. Introduction

Knowledge of differences in the thought processes and knowledge structures of novices and experts has important implications for both instructors and students in a skill acquisition setting as they attempt to provide optimal instruction for the learners' development and achievement of complex skill performance.

Novice-expert differences in thought processes and knowledge structures have been studied in a variety of fields such as physics problem solving (Chi, Feltovich & Glaser, 1982), chess playing (Chase & Simon, 1973 a,b), mathematics teaching (Lienhardt & Smith, 1986), physical education teaching (Housner & Griffy, 1985), gymnastic performance (Vickers, 1986, 1988), badminton game (Housner,1981), basketball and baseball games.(Allard and Burnett, 1985)

Though sport skills and cognitive tasks are different in some aspects, (e.g., the relatively high requirement of concurrent complex motor skill in the former and a lesser requirement in the latter), it has nevertheless been suggested that in other aspects there are many similarities between experts in cognitive tasks and sports experts (e.g., Allard & Burnett, 1985; Housner, 1981; Vickers, 1990). It should be profitable, therefore, for teachers and coaches of sport skills to examine the performers' cognitive processes and knowledge structures in order to improve the learning environment and to better understand their skill performance, particularly in the case of open skilled activities such as game sports. The smooth functioning of open skill action depends on the learners' capability to adapt

to an ever changing environment. As Magill (1989) states in his review of Gentile's (1972) study, "the movement pattern learned in the first stage must be practiced but with the goal to diversify the variations of the pattern that can be produced" (P.69).

How do we develop from the novice to expert level of performance? Anderson (1982, 1985) suggests a three stage progression, that is, from the declarative stage to the knowledge compilation stage and finally to the procedural stage. In his theory, he describes how rules and facts (declarative knowledge) are interpreted at first, then compiled and gradually proceduralized in a refined manner. Dreyfus and Dreyfus (1986a, b) present their progression in terms of a five-stage theory derived from their work in the artificial intelligence field which attempts to produce the computer counterpart of the human expert. Jewett and Mullan (1977) describe seven stages of qualitative change that occur in the development of movement efficiency and this is presented in "Movement Process Categories".

These stage theories focus on the qualitative changes associated with the skill acquisition which occurs as one progresses from the novice to the expert level. Chi and Glaser (1980) stress the importance of these "qualitative changes in the long-term development of competence" rather than the "immediate product of short-term learning and achievement" (p.40).

> One important implication of the qualitative changes in the long-term development of competence is that different modes of learning are active at the different stages of the acquisition of skilled performance. As a result, the level of performance attained needs to be assessed and then matched with appropriate instructional conditions in order for further expertise to be developed." (p.46)

From a review of these studies, it is clear that it is important for teachers and coaches to comprehend the structuring and use of knowledge in the sequential development of skill acquisition.

"Learning is a set of processes."(Schmidt ,1988; p.346). Schema /schemata (Anderson,1985; Schmidt, 1988; Neisser, 1976) or knowledge structures which are established on the basis of the experience seem to grow and transform in association with additional practice and expression. Allard and Burnett (1885) emphasize that "skill development and schema development are synonymous" (p.303)

Teaching influences students' thinking and students' thinking mediates the interaction of learning and achievement (Wittrock, 1986). As we view learning as an active and constructive process (Shuell, 1986), the investigation of the cognitive processes of learners in the real world and an understanding of how the related knowledge structures develop will surely provide more effective instruction for skill acquisition.

In this study, novice tennis players' thought processes were explored over the final four weeks of a 12 week instructional session. Multiple case studies utilizing the interview technique were conducted. Qualitative and inductive methods relating to the analysis of the subjects' verbal reports were employed in order to reveal the most vivid descriptions of the participating novice tennis players' thought processes. Quantitative measures of data using the CompuTennis scoring sheets of performance were also collected over the duration of the investigation. Although knowledge about skilled action and thought processes might remain at a tacit level (Newell and Barclay, 1982; Vickers, 1990), it is assumed that appropriate interview techniques applied just after the performance will

reveal players' thought processes and knowledge structures in an explicit manner (Tuckwell, 1980).

It was intended that this study would lead to a series of future studies that would trace the development of players' thought processes and knowledge structures from the novice to the expert level of performance.

1.2. Purpose of This Study

The basic purpose of this study was to better understand the development of a performer's knowledge structure by the examination of his/her thought processes in action. In this instance, the focus was upon novice tennis players and their actions as they learned to perform during game situations. This basic purpose was further divided into two sub-purposes:

1. To record and explore novice performers' thought processes during a skill instruction experience.
2. To examine the development of their knowledge structure with a view to relating the finding of this examination to current status of "novice to expert" expectations.

1.3. Study Questions

In relation to the purpose of study, this study focused on the following questions:

1. What patterns of knowledge organization exhibit themselves in the self report of novices.
2. Is there a relationship between novice knowledge structure as derived from the nature of the thought processes and the playing ability at this level?
3. Are individual differences in thought processes and knowledge structure apparent over the period of four weeks?

1.4. Significance of This Study

The nature of the knowledge structure which is the foundation of an expert's performance decisions and actions can, at this time, only be speculated. Although researchers have formulated theoretical frameworks of the context, organization and interrelationships of the elements of knowledge, it was felt that practising teachers and coaches would benefit from the results of an exploratory investigation.

To initiate such a project, this study proposed to describe the features of the thought processes and the knowledge structures of the novice as the first step in a series of studies that intended to track progressive development to the expert level.

Recent studies relating to learning have indicated the importance of the effect of the learner's thought process and knowledge structure as a mediator of the teaching - learning process (Weinstein & Mayer, 1986). Teachers' and learners' thought processes have been examined in relation to, for example, their attention, decision making, motivation and knowledge structure (Wittrock, 1986; Clark & Peterson, 1986). Although

Allard and Burnett (1985) indicate that there is a certain amount of parallelism between skill development and the development of cognitive processes, there has been only one empirical study (Housner, 1981) of the thought processes in the actual open skill sport performance situation.

The present study set out to provide vivid and accurate descriptions of thoughts of novice tennis players while they were performing in actual tennis games. It was anticipated that, from these descriptions, we would be better able to understand their patterns of thought processes and knowledge structures and progressive thought development. As Neisser (1976) suggested the focus was more "on the real world in which perceivers and thinkers live, and the fine structure of information which that world makes available to them: (p.8)

Each player's thoughts (e.g., response selections) and resulting performance (response execution) were to be examined simultaneously as interrelated phenomena. Any strong associations with respect to the interrelationship of the two may prove to be valuable information in terms of the design of future instruction of novice tennis players. Moreover, as this study was conducted over a four-week period for each player (once a week for four weeks), it was expected that certain changes in players' thought processes would occur. If, in fact, anticipated changes did occur, they would be noted and the developmental process of players' thought and knowledge would be documented. However, it should be reiterated that the most significant point of this study was to explore what was "going on" in the players' mind while they were playing with a view toward an insight regarding the potential development of their knowledge structures and the implication for instructional decisions.

1.5. Definition of Terms

Cognitive map

"An abstraction which refers to a cross-section, at one point in time, of the environment as people believe it to be." (cognitive mapping--- "A construct which encompasses those cognitive processes which enable people to acquire, code, store, recall and manipulate information about the nature of their spatial environment.") (Chase & Chi, 1981:131-132)

"A synonym for "orienting schema" which is an active information-seeking structure. Instead of defining a cognitive map as a kind of image, I (Neisser) propose that spatial imagery itself is just an aspect of the functioning of orienting schemata. Like other schemata, they accept information and direct action." (Neisser, 1986; p.111)

Cognitive process

"The mental functions assumed to be involved in perception, learning, and thinking." (Goldenson, 1984; P.155)

Contextual knowledge

"'Knowing when and why' to employ specific concepts, rules and principles for given domain- dependent situations." (Tennyson & Rasch, 1988; p.372)

Declarative knowledge

"The knowledge that something is the case, as opposed to the knowledge of how to do something (procedural knowledge)". (Sutherland, 1989; p.109)

"... implies an awareness of domain-dependent information and refers to the 'knowing that'." (Tennyson & Rasch, 1988; p.372)

Free recall

"During the stimulated recall, the participants voluntarily stop the video tape and make comments on their performance of their choice at will."

Knowledge structure

"Those coherent, large-scale memory units that serve to direct performance component and that can help to utilize context information to derive expectations and interpret environmental input." (Gardner, 1985; p.170)

Procedural knowledge

"Knowing how to do something." (Sutherland, 1989; p.346)

"'Knowing how' to employ domain-dependent concepts, rules and principles." (Tennyson & Rasch, 1988; p.327

Production rules (production systems)

Production rules and production systems refer to the mechanism and conditions that link cognition with action. More specifically, both these terms refer to the mechanism that transforms knowledge to action. Production rules contain condition side (IF) and action side (THEN). "Production systems", "production rules" and even "productions" are most of the time used interchangeably. In some occasions, a slight distinction is made between them, a production rule is a rule that applies to a very specific, individual situation such as a rule which applies to one step in a sequence of steps of some action.

On the other hand, production systems refer to a collection of such rules. For example, in the situation of problem-solving, "production systems consist of a set of productions which are rules for solving problems" (Anderson, 1985; p.220). "Procedural knowledge can be represented as a set of production rules, which are condition-action pairs" (Chi,1987; p.247).

Schema (Schemata)

"A rule or set of rules that serves to provide the basis for a decision. ...it is developed from abstracting important pieces of information from related experiences and combining them into a type of rule." (Magill, 1989; p.82)

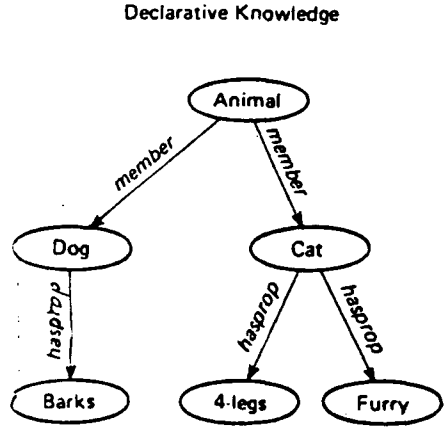
"Portion of the entire perceptual cycle which is internal to the perceiver, modifiable by experience, and somehow specific to what is being perceived. The schema accepts information as it becomes available at sensory surfaces and is changed by that information; it directs movements and exploratory activities that make more information available, by which it is further modified." (Neisser, 1976; p.54)

"A large, complex units of knowledge that encode the typical properties of instances of general categories. "(Anderson, 1985; P.103).

"A plan, an outline, a structure, a framework, a program, etc. In all or any of these meanings the assumption is that the schemata (or schemas) are cognitive, mental plans that are abstract and that they serve as guidelines for action, as structures for interpreting information, as organized frameworks for solving problems, etc.." (Reber, 1985; p.665).

Semantic net

"A method of storing information about the world in a computer program and, some think, in the brain; it is based on a series of labelled nodes connected by labelled arrows to other nodes. The labels represent objects, properties, and relations. Although they are not words, they are usually (confusingly) written as words. Thus the node for dog might be labelled 'dog' and have the following arrows and nodes (the word before the arrow is the label of the node to which it points). Dog: subordinate of → mammal; subordinate of → pet; property → barking." (Sutherland, 1989; p.396)
Chi (1987) present a figure of a semantic propositional network in order to explain declarative knowledge.



"Declarative knowledge can be represented in terms of a semantic propositional network, where a concept (such as a dog) may be represented as a node, and links specify the relationships among the nodes. Hence, the proposition that 'a dog is an animal' could be represented by two nodes, with an *isa* link between them." (Chi,1987; p.247)

Stimulated recall

"A branch of introspective methodology in which video tape recordings of conference.(i.e., in this study, tennis game) behavior are used to facilitate participants' recall of the covert mental activity which was occurring simultaneously with the recorded overt behavior." (Grimmett, 1982; p.14)

"A technique for gathering retrospective reports of verbal and nonverbal thought processes under conditions of explicit and informationally rich recall cues regarding a well-circumscribed event.' (Shavelson et al., 1986; p.83)

Structured recall

In the stimulated recall method, during which interviewer-controlled, specific structured questions are provided while the participants are viewing their own performance in the video tape replay.

Thought process

"A general term for any type of thinking or symbolic process involved in such activities as judgements, imagination, problem-solving, and drawing inferences." (Goldenson, 1984; p.748)

Working memory

"The current contents of consciousness, a temporary store in which items from long-term memory or from perception may be placed, and in which they may be manipulated." (Sutherland, 1989; p.480)

"Portion of memory currently in a highly active or accessible state, that is, whatever is being processed or attended to at any given time." (Kyllonen & Christal, 1989; P.155)

Kyllonen & Christal (1989) mention that there are two different forms which describe working memory in the literature. "One is *processing workspace* model and the other is *activation capacity* model. The *processing workspace* model of working memory "proposes a limited, consciously-controlled, short term memory capable of storing roughly three to nine items at a time. The capacity of this structure is determined mostly by how efficiently one processes new incoming information." (Kyllonen & Christal, 1989; P.155). The *activation capacity* model, "based primarily on Anderson's (1987) ACT* theory, defines working memory not as a separate short-term store, but rather as a state of fluctuating activation patterns characterizing traces in long-term memory. According to this theory, long-term memory is a network of traces, each characterized by resting activation levels. Traces become activated when they become the focus of attention, or are linked to the focus of attention, then fade into a state of deactivation as other traces move to the center of focus. Working memory is said to be a 'matter of degree' rather than an all or none state, in that at any moment a trace might be the focus of attention (and thereby be at a peak activation level) or it might be continuously fading from attention, if, for example, it was the focus a few seconds earlier." (Kyllonen & Christal, 1989; P.159)

2. LITERATURE REVIEW

In order to better understand human knowledge structure and thought precesses and their development in relation to skill acquisition, a literature review was carried out. The pertinent literature was categorized into three areas.

Firstly, a review is presented to summarize the pertinent literature which discusses the nature, type and organization of knowledge structures pertaining to skill acquisition. Secondly, a review is presented to summarize the literature regarding the recent novice-expert paradigm studies which have investigated the characteristics of knowledge organization in the context of skill performance by novices in contrast to that by experts. Thirdly, a review of literature is presented dealing with selected stage theories of skill acquisition.

2.1. Knowledge Structure in Skill Acquisition

The nature and representation of knowledge and problem solving have been the subject of study during the past two decades in relation to skill acquisition and learning (Glaser, 1984). How new knowledge is structured and integrated with prior knowledge is an important concept regarding the skill acquisition.(Allard & Burnett, 1985; Glencross, 1978; Shuell, 1986).

Gardner (1985) defines knowledge structures as :

> Those coherent, large-scale memory units that serve to direct performance components and that can help utilize context information to derive expectations and interpret environmental input (p.170).

Newell and Barclay (1982) describe how knowledge might be represented in the information processing system:

> In one sense, knowledge is the product of the organism-environmental interaction. If this assumption is made, then knowledge is equivalent to the organism's current level of adaptation. In another sense, knowledge is the process through which the organism interacts with the environment. Given this view, knowledge represents a set of procedures for adaptation. Regardless of whether knowledge is an architectural feature of the system or a tendency to adapt in a certain way, it affords the degree to which the organism adjusts to changing environmental process. (p.205)

In the sport situation, open skill particularly involves a large number of cues to encode, infer and select in order to make decisions within the information processing system. It is critical for a performer to develop a broad knowledge of the particular sport from his/her experiences and to organize it in a manner that will enable appropriate decision making at appropriate times (Allard & Burnett, 1985; Whiting, 1982; Fumoto, 1989). It is clear that all of our actions are guided by some form of knowledge structure, and that practice facilitates the qualitatively refined formation of the knowledge structure.

Cognitive psychologists currently distinguish mainly between two different types of knowledge which pertain to different memory systems or functions. Declarative knowledge is considered to be knowledge "about" things. It implies an awareness of domain-dependent information or function and refers to "knowing that". Procedural knowledge implies

"knowing how" to employ domain-dependent concepts, rules and principles. Anderson (1982) suggests that all new knowledge is encoded, at first, declaratively and is represented in the semantic network. "In a declarative encoding, the knowledge required to perform a skill is represented as a set of facts." (Neves & Anderson, 1981, p.60). Then the declarative knowledge is gradually compiled and transformed to procedural knowledge by the learner. [The sequential stages by Anderson will be discussed in a later section 2.3.3: Anderson (1982): Three Stages of Skill Acquisition .]

The procedural knowledge can be represented as "production systems". Anderson's (1982) ACT (Adaptive Control of Thought), which is developed as a computer program, is capable of learning procedural knowledge in skill acquisition. ACT production systems display IF-THEN rules to demonstrate how the condition and action are interrelated in a production system. "Production systems consist of a set of *productions* which are rules for solving problems" (Anderson,1985; p.220) Anderson (1985) presents an example of production rules as follows:

IF the goal is to drive a standard transmission car
and the car is in first gear
and the car is going more than 10 miles an hour
THEN shift the car into second gear

> Such production is organized into a condition and an action. The *condition* consists of a statement of the goal (i.e., to drive a standard transmission car) and of certain tests to determine if the rules is applicable to the goal. If these tests are met, the rule will apply and the action (i.e., shifting the car into second gear) will be performed. (Anderson,1985; p.220)

Moreover, Chi (1987) comments on these production rules in relation to the semantic network which represents the declarative knowledge, as follows:

> The condition of a production rule specifies a feature or set of features that must match either the content of working memory (such as stimulus inputs that are stored there temporarily) or the structure of the activated portion of the semantic network. Hence, in a way, the condition side of a production rule takes as argument the structure of the declarative knowledge, and the action side constitutes procedures that either modify or add to the semantic structure, or manipulate an external environment. (p.247)

Anderson's theory of production systems explicitly presents the relationship between declarative and procedural knowledge. Moreover, this theory clarifies the progression of the thought process and knowledge structures from novice to expert level in skill acquisition. Emphasis is on "learning by doing" (Anderson, 1982) and ".... expertise comes about through the use of knowledge and not by analysis of knowledge" (Neves & Anderson, 1981; P. 83). Chi and Glaser (1980) integrate the production system into the measurement of expertise. They speculate that:

> ...for the expert, a standard problem requires only the retrieval of prestored production systems, whereas a novel or a difficult problem may require the organization of a new set of productions. For the novice, however, every problem may require the latter type of constructive assembly process to reach a solution. (p.41)

Similarly, Dreyfus and Dreyfus (1986b) discuss the knowledge base for the representation of the expert in an artificial intelligence system. "Expert system" has been developed in the computer field as a recent subject of machine intelligence. Besides the common sense understanding which consists of a vast body of proposition, belief, rules, facts and

procedures, the special knowledge for "the expert system" in a particular field is: (1) the facts of the domain, which make for the wide content knowledge; (2) heuristic knowledge which is the knowledge of good practice and good judgment in a particular field. Dreyfus and Dreyfus (1986b) discuss the problems of this heuristic knowledge: how the human experts compile their heuristic knowledge. Knowledge engineers, who try to construct an expert system close to the human expert, find it quite difficult to reconstruct human experts' thought processes and knowledge structures because the human experts are already in the autonomous stage. . Therefore, Dreyfus & Dreyfus (1986a,b) suggest the necessity to examine the progressive stages from novice to expert in order to fully understand the human expert. ["The Five Stages of Skill Acquisition" by Dreyfus & Dreyfus (1986a,b) is discussed later in the section 2.3.1.]

Tennyson and Rasch (1988) examine conjunctive learning theory with respect to instructional design. They approach instructional design by considering the acquisition, retrieval and extension of knowledge, as well as thinking strategies. In their study, they differentiate the knowledge base into three categories pertaining to the amount, organization and accessibility of knowledge. Declarative knowledge is defined similarly as other researchers have done, such as, Anderson (1982), Chi (1987) and Chi,Glaser and Farr (1988). In addition to this declarative knowledge, they refer to "contextual knowledge" and differentiate it from procedural knowledge. Tennyson and Rasch (1988) define contextual knowledge as follows:

> Contextual knowledge implies "knowing when and why" to employ specific concepts, rules, and principles for given domain-dependent situations. This cognitive skill of knowing when and why to employ

> information is governed by selection criteria embedded within the organization of the knowledge base. Selection criteria are the standards, values, and situational appropriateness by which information within a given domain is employed. Whereas both declarative and procedural knowledge form the amount of information in a knowledge base, contextual knowledge forms its organization and accessibility..(p.372).

In their theory, procedural knowledge is considered as domain-dependent, and is related to such matters as the forming of the amount of knowledge and how a learner uses the facts, concepts, rules and principles correctly. On the other hand, contextual knowledge is more situationally oriented and is described as production systems (i.e., IF-THEN). They state that one of the purposes of education is to increase the domain specific contextual knowledge, to retrieve stored knowledge and to develop contextual criteria.

At this point, it is appropriate to discuss some differences in Tennyson and Rasch's conceptualization of procedural knowledge and that of other researchers. The procedural knowledge as defined by Tennyson and Rasch does not seem to be related to situational cues . For example, in the tennis performance situation, knowledge such as how to hit a forehand ground stroke in which there are no game cues involved would be considered procedural knowledge. However, when knowledge is generally differentiated by other authorities into declarative and procedural knowledge categories, procedural knowledge refers to a much deeper and broader concept. Procedural knowledge means in this situation not only how to execute good forehand ground stroke technique, but also where and when to hit the forehand ground stroke in a game situation. This broader interpretation of procedural knowledge includes some domain-specific situational knowledge and strategic knowledge as well.

Singer (1982) define and explain strategy as:

> A strategy is a skill of self-management that the learner acquires to govern the processes of attending, learning, and thinking; it governs behavior. By using a strategy, a learner imposes some type of structure on cue and movement information so that an act or information is learned and retrieved more effectively. He or she makes an association of what works in the particular situation. (Singer, 1982; p.187).

Therefore, in the procedural stage of Anderson's theory, the mechanisms such as discrimination, generalization, and strengthening seem to be similar to certain characteristics displayed by a highly skilled performer with respect to his retrieval of contextual knowledge, where organization and accessibility of knowledge are important characteristics.

In the present study, Anderson's distinction of declarative and procedural knowledge will be employed for the following reasons:

1. His theory explains in a more detailed way how the declarative knowledge is acquired and compiled to become procedural knowledge in particular situations.

2. His theory is more prevalent in the literature and therefore, the concept of Anderson's definition of procedural knowledge will be more generally understood by the readers.

2.2. Novice and Expert in Skill Acquisition

For the purpose of more efficiently achieving higher levels of performance, people have generally acknowledged the importance of understanding the stages of progression from novice to expert, and more

specifically, of understanding the characteristics of an expert with regard to his /her thought processes and knowledge structures.

Chi and Glaser (1980) stress the importance of the investigation of progressive changes which occur from novice to expert level:

> The question that needs to be asked is whether the assessment procedures and related teaching sequences currently in use have any relation to sequences that would be optimal for producing not only beginning but advanced level of achievement. (p. 38)

Allard and Burnett (1985) discuss the similarity between sport skill performance and cognitive skill performance such as chess play from the cognitive point of view. They comment that sport experts possess cognitive skills of their domain that are very similar to experts in other skill domains. Their study shows similar chunking and categorizing performance for sport experts as are found for experts of cognitive skills. (The details of their study will be discussed later in this section.)

In the sport situation, generally, closed skill performance and open skill performance have somewhat different characteristics in relation to the demands of their respective environments. The attention of the closed skill performance is primarily, internal, where the performer attempts to produce an ideal motor pattern, thus realizing a successful outcome. On the other hand, the attention demands of an open skill performance are primarily external where cues such as the performers' position in relation to the opponent must be identified and monitored. Therefore, it is useful, when considering open skill performances, to examine the characteristics of novices and experts related not only to the overt sports skill performance, but also to the associated cognitive skills such as chess playing, and because of the similarities that exist in the focusing of

attention on the environment and in the decision-making processes. We must, nevertheless, be aware of the differences between the nature of sport skill and cognitive tasks (i.e., the relatively high requirement of complex motor skill and physical demand in the former and lesser requirement in the latter).

Vickers (1986, 1988) conducted studies which required the cognitive reconstruction of gymnastic movement sequences. Subjects, with three different skill levels, were asked to reconstruct a set of photographs of gymnastic movements into the proper sequence of movements as quickly and as accurately as possible. The time and error frequency were recorded with the results showing that the elite gymnasts resequenced such photographs with less time and fewer errors than the two lesser skilled groups. In this study, the focus was on the gymnasts' perceptual skills. It appeared that the different levels of skill performers attended to different set of information cues from the same pictorial environment. The higher proficiency level gymnasts identified more of the "regulatory" performance cues and did so much faster than the lower level proficiency gymnasts.

Fumoto (1989) also refers to a study conducted by Kanamoto et al (1979) who analyzed the eye movements and fixations of goal keepers who have different experiences. In a two-on-one situation, the experienced goal keeper looked alternately at the ball and the two opponent players who were trying to score. The experienced goal keeper's back-and-forth eye movements between the ball and the attacking players was faster and the duration of his eye fixations on each was shorter than was the case with the inexperienced goal keeper who focused on the ball location for a longer time. This study indicated that the experienced goal keeper pays more

attention to the important situational cues which are changing quickly, as the basis of their decision-making process. As Vickers (1986) describes, the experienced performer can identify the important cues in a particular situation. Fumoto(1989) suggests that this comprehension of the situation by performers should be a part of their schema, and learning means the acquisition of a broad schema which is based on the cognition of the situation.

Similarly, a study by Bard and Fleury (1976) found that expert basketball players demonstrated statistically less number of fixations of attention than non-players, although decision time was not significantly different between groups. The players' task was to identify the correct option among several possibilities (e.g., shoot, dribble) as presented in a slide projection of a game situation and to verbalize their answers when they were shown a set of slides which presented a series of offensive basketball situations.

The similar characteristics of experts shown in the three studies above can be analyzed in terms of their developing knowledge structures and cognitive processes. To be "expert" in a particular domain means that one has a broader knowledge base. Expert's semantic networks are "dense, containing clusters of related information, whereas the network for the novice is sparse, with relatively few highly interrelated clusters" (Chi & Glaser, 1980; p.39). Moreover, experts' knowledge contains not only broad declarative knowledge (i.e., knowing that), but also broad procedural knowledge (i.e., knowing how) and solution strategies as the result of many years of experience to handle the situations, whereas, a novice seems not to have many solution methods or alternatives.

The studies by Chase and Simon (1973a, b) examined the cognitive processes of chess players. They focused on what the expert chess player perceived. They found that a master chess player encoded the chess position into larger perceptual chunks, each consisting of familiar subconfiguration of pieces. They also suggest the existence of abstract relationships between chunks and hierarchical organization of the chunks related to chess skill. The expert was able to take in more information in a single glance than the less skilled performer: the expert could recognize, at a glance, pieces and functional relationships between pieces. The expert had a very large repertoire of patterns in long term memory. He organized the moves of the game in terms of the perceptual structures and their alternatives as the game proceeded. The novice, on the other hand, had in his long term memory, smaller chunk size of patterns than the expert, and consequently, he had difficulty in the ability to recall and reconstruct the chess board.

Other researchers (e. g., Reitman & Rueter,1980; Glencross,1978; Vickers, 1990) also suggest the concepts of chunking and the hierarchical orders concerning the mental organization in performers' knowledge structure. Reitman and Rueter (1980) refer to this mental structure as the "order tree". They suggest experts organize order trees in a more meaningful way than novices. Similarly Leinhardt and Smith (1986) found a more refined hierarchical structure of knowledge by the expert teachers in the sorting task of mathematics instruction.

The study by Chi, Feltovich and Glaser (1981) examined the categorization and representation of physics problems by experts and novices. One item of investigation had to do with the task of the sorting of physics problems into groups based on similarities of solution. After the

sorting, the subjects were asked to explain the reasons for their grouping. No quantitative difference (i.e., the number of categories produced by each group) was found in this study. However, there were differences between the categorization of the problems. The novices categorized the problems by "surface structures" which might involve either key words given in the problem statement or abstracted visual configuration. On the other hand, the experts completed their classification according to the major physics principle governing the solution of each problem. The experts saw " deep structures" which related to the law of physics applicable to the problem.

Another purpose of this study (Chi, Feltovich & Glaser, 1981) was to assess the kind of knowledge that might be associated with the schemata when the categorization process was described by the subjects. Both novices and experts presented the same sets of key words, but the experts had additional knowledge including potential solution knowledge (i.e., procedural knowledge) based on major physics laws.

The last item investigated by Chi, Feltovich and Glaser (1981) was to determine the "basic approach" that subjects would take toward solving the problems. The verbal reports by the subjects using "think loud method" was examined. The experts, as it is mentioned in the discussion of the preceding point, categorized problems according to an abstract solution procedure, and showed almost total agreement among themselves regarding the principle they would apply. On the other hand, the novices were unable to formulate solution method.

> For experts, it was suggested that this process occurs over a span of time and involves interplay between the problem statement and the knowledge base--even during the reading of the problem. Literal cues from the problem statements are transformed into second-order

> (derived) features which activate a category schema for a problem type (Chi, Feltovich & Glaser, 1981).

The authors suggest, through their study, that the schemata in novices contains sufficiently elaborate declarative knowledge about the potential problem configuration, but the schemata in experts contains a great deal of procedural knowledge for problem solving process.

Housner (1981), in the context of badminton games, examined novice-expert differences with regard to their strategic knowledge structure and the cognitive processes which the performers indicated that they employed during game play. There were two phases in this study:

> The purpose of phase I was to gather information pertaining to the structure of the strategic knowledge base of the expert and novice. Phase II was designed to explore the way in which the expert and novice employ their strategic knowledge structures and the types of cognitive processes employed as they plan for and compete in a game of badminton (p.4).

During phase II, interviews were given before, during and after the games. Structured questions were given to the players in phase I and II.

Phase I of this study revealed that the expert possessed a strategic knowledge structure "which was comprised of more strategic concepts, more production systems and more interconnections between concepts than the novice" (p.10). Figure 1a and 1b present the knowledge differences which appear to exist between the novice and the expert players.

Phase II was conducted to explore the novice's and expert's employment of strategic concepts during the badminton game.

> The expert was found to employ an information gathering solution strategy characterized by the chunking of game events into probability or summary statements and the use of evaluative and shot selection statements as a mode of semantically analyzing the flow of

Figure 1a. Knowledge structure of a novice badminton player
-- Housner's model --

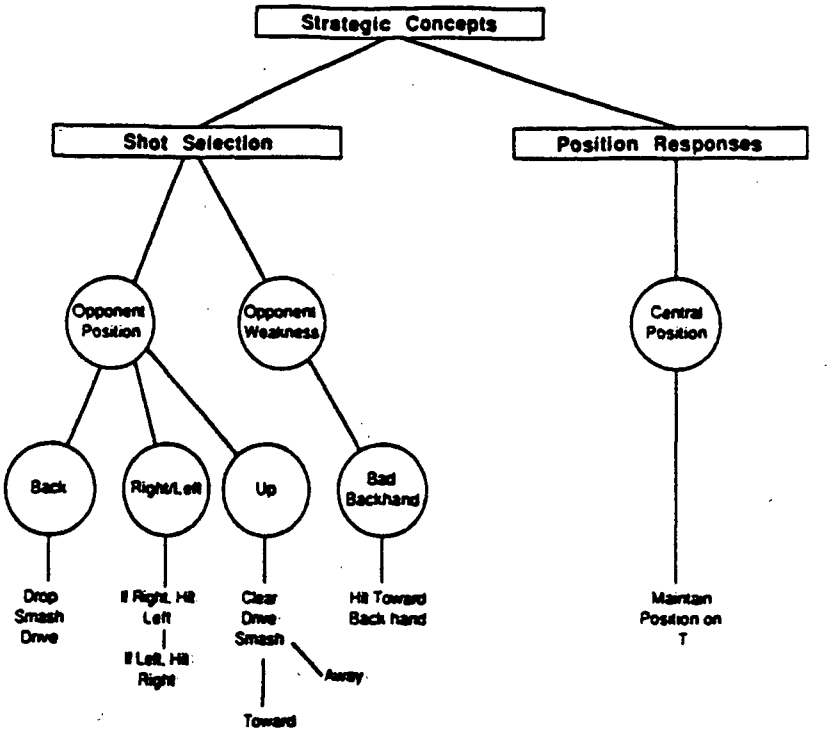
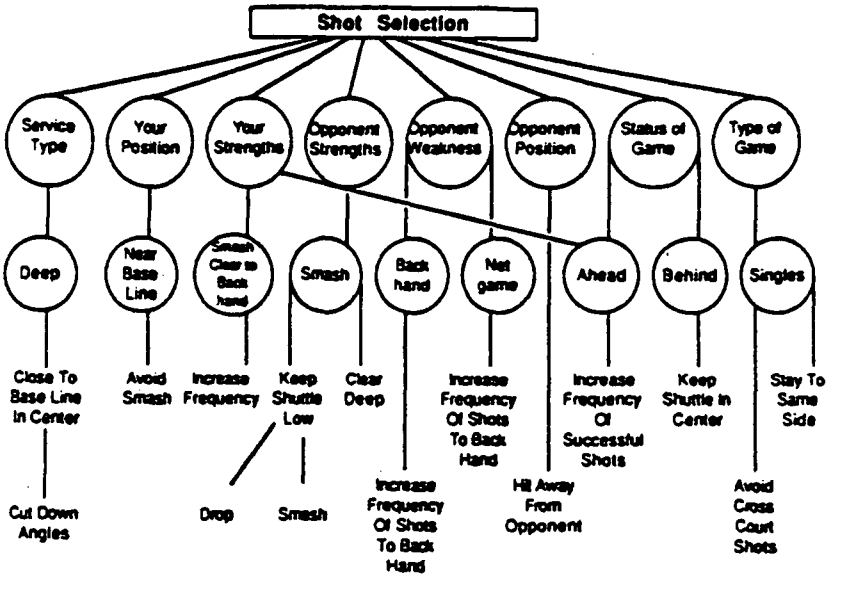


Figure 1b. Knowledge structure of an expert badminton player
-- Housner's model --



From "Skill in badminton" by L.D. Housner (1981) quoted in Vickers' (1990) Instructional Design for Teaching Physical Education, P. 33-34.

> action during the game. The novice, however, was not found to employ these solution strategies, but rather relied on a straightforward application of a small number of stored strategic concepts (p.16).

Housner concluded that the result of this study revealed that "substantial knowledge structure and cognitive processing differences existed between an expert and a novice badminton player" (p.16). Moreover, the results of this study suggest that "the expert-novice paradigm is an effective approach to investigating the cognitive aspects of sport" (p.17), and this paradigm implies an instructional program which would assist the novices to develop their strategic concepts of badminton.

Allard and Burnett (1982) attempted to demonstrate that sport experts possess cognitive skills very similar to that of expert in other domains. They applied the method of recall task used by Chase and Simon (1973a,b) and sorting task used by Chi, Feltovich and Glaser (1981). First of all, they examined whether basketball players and non-players could demonstrate recall of the information in selected representations of basketball game situations. The subjects were presented with a schematic diagram of a basketball play drawn on a piece of paper. The subjects studied the diagram for 5 seconds, then reproduced the diagram as thoroughly as they could. Then they studied for another 5 second period and added to the drawing using a different color marker. This procedure was repeated until the subjects were satisfied with their drawing. The subjects were presented with 10 play situations in all, one diagram at a time. The result showed that expert players were able to take in more information in one "look". Although the researchers admitted that these diagrams did not show the coding of actual play such as the characteristics of players and the temporal relationship of the movement of the players in

a diagram, the subjects were required to place an interpretation on the situation. Nevertheless, expert basketball players displayed organized semantic network to complete this recall task, whereas the non-players did not.

Secondly, Allard and Burnett (1982) attempted the sorting tasks used in the study on solving problems by Chi, Feltovich and Glaser (1981). Expert basketball players and non-players were asked to sort the pictures of basketball into categories using whatever rules they wished to use. The result showed that the expert players sorted into more categories, and sorted the pictures in relation to the strategy of the actual game situations such as various defence-offence situations. Moreover, these situations were distinguished between the situations of the individual players and that of the team plays. On the other hand, non-players sorted the picture into only two categories of individual players' fundamental skills and team play. They sorted the pictures without considering the game situation and just sorted into superficially similar skills.

Allard and Burnett (1982) concluded from the results of the two studies that expert basketball players possessed deep structures in their knowledge bases which were similar to the results of chess player and physics problem solving studies.

Another component of the experts' characteristics which perhaps deserves some special mentioning is strategic skill. Singer (1982) defines strategic skill as:

> a skill of self-management that the learner acquires to govern the processes of attending, learning and thinking: it governs behavior. (P.187)

Further, Singer (1982) emphasizes that:

> the ability to self-control and self-regulate, and to be able to do this consistently, is the mark of highly proficient performers. (p. 187)

Similarly, Chi and Glaser (1980) and Chi, Glaser and Farr (1988) indicate that one of the characteristics which the experts possess is a variety of cognitive strategies toward problem solving. Experts exhibit superior performance in the development of solution strategies, planning and self-inquiry.

Finally, Posner (1988) points out the importance of individual differences in any discussion about experts. Although the progressive stages from novice to expert are not considered for the people who have gifted capability, we must be aware of the various factors necessary to produce an expert. Individuals may differ in overall ability or particular abilities. Another important factor is motivation. It is essential to remain highly motivated for the long, continuous training necessary to achieve highly skilled level performance. These basic capabilities and interests may interact with the acquisition of information from the environment to produce expert performance.

2.3. Stages of Skill Acquisition

Learners appear to pass through qualitatively different stages or phases as they practice and acquire a skill. In this section three studies are reviewed to examine the stages of skill development: "Five stages of skill acquisition" (Dreyfus & Dreyfus,1986,a,b), "Movement process categories" (Jewett & Mullan 1977) and Anderson's (1982) three stages (i.e.,

declarative, knowledge compilation and procedural stages) which emanated from the Fitts (1964) three phases of learning.

In addition, the National Tennis Rating Program (NTRP) developed by the United States Tennis Association is explained in order to clarify the stages in terms of actual tennis skill performance characteristics.

2.3.1. Dreyfus and Dreyfus (1986a,b): Five stages of skill acquisition

Dreyfus & Dreyfus (1986a,b) differentiate five stages through which learners progress as they acquire skill: novice, advanced beginner, competent, proficient and expert.

During the first stage of skill acquisition, novice learners learn to recognize facts and rules which are treated as context-free features. These elements are decomposed from the real situation, so that the novice can learn without the experience of the task. "The beginning student wants to do a good job, but lacking any coherent sense of the overall task, he judges his performance mainly by how well he follows his learned rules" (1986b ; p.321).

When the learners' experiences increase, they gradually begin to adapt to the real situation or actual context. In the advanced beginner stage, they learn "an enlarged concept of the world of the skill" (1986a; p.22). Not only the learners are taught, but also they learn to recognize the more precise components of the situation. Therefore "situational" as well as "context-free" components are seen in this advanced beginner stage.

With increasing experience, the performer learns to deal with the vast amount of information in the situation and they enter into the stage of competence.

> To cope with this information explosion, the performer learns, or is taught, to adopt a hierarchical view of decision-making. By first choosing a plan, goal or perspective which organizes the situation and by then examining only the small set of features and aspects that he has learned are the most important given that plan, the performer can simplify and improve his performance (1986b; p.322).

The competent learners also feel responsible for the the result of their choice, therefore, they are emotionally involved in the result of their performance outcomes although they understand and decide in a detached manner.

At the proficiency stage, the learners are deeply involved in their tasks and they experience these tasks from specific perspectives which were obtained from previous experiences.

> Because of the performer's perspective, certain features of the situation will stand out as salient and others will recede into the background and be ignored. As events modify the salient features, plans, expectations, and even the relative salience of features will gradually change. No detached choice or deliberation occurs (1986a, p.28).

Now the proficient performers have started to possess "intuitive ability" to perform unconsciously. However,"the proficient performer, while intuitively organizing and understanding his task, will still find himself thinking analytically about what to do" (1986a; p.29). They have to assess their decisions in particular situations and involvement in the skill performance is temporarily broken.

At the last stage, experts do not make conscious deliberate decisions and they do not appear to be aware of what they are doing. "*Then things are proceeding normally, experts don't solve problems and don't make decisions; they do what normally works*" (1986a; p.30-31). When they

have to make decisions at critical moments, "they intuitively see what to do without applying rules" (1986b; p.326). They possess an immensity of recognizable situations from their experience, and their related decisions are fast; therefore, their performance is fluid and coordinated.

In summary, Dreyfus and Dreyfus (1986a) describe the stages which are involved in the learner's changes in perspective and behavior during skill acquisition as follows:

> What should stand out is the progression *from* analytic behavior of a detached subject, consciously decomposing his environment into recognizable elements, and following abstract rules, *to* involved skilled behavior based on an accumulation of concrete experiences and the unconscious recognition of new situations as similar to whole remembered one (p.35)

Table 1 presents a summary of Dreyfus and Dreyfus's (1986a) "Five stages of skill acquisition".

Table 1. **Five Stages of Skill Acquisition**

Skill Level	*Components*	*Perspective*	*Decision*	*Commitment*
1. Novice	Context-free	None	Analytical	Detached
2. Advanced beginner	Context-free and situational	None	Analytical	Detached
3. Competent	Context-free and situational	Chosen	Analytical	Detached understanding and deciding. Involved in outcome
4. Proficient	Context-free and situational	Experienced	Analytical	Involved understanding. Detached deciding
5. Expert	Context-free and situational	Experienced	Intuitive	Involved

From

Dreyfus, H. L. & Dreyfus, S. E. (1986) Mind over Machine: the Power of Human Intuition and Expertise in the Era of the Computer p.50.

Figure 2.

MOVEMENT PROCESS CATEGORIES*

A. Generic Movement: Those movement operations or processes which facilitate the development of characteristic and effective motor patterns. They are typically exploratory operations in which the learner receives or "takes in" data as he or she moves.

1. Perceiving: Awareness of total body relationships and of self in motion. These awarenesses may be evidenced by body positions or motoric acts; they may be sensory in that the mover feels the equilibrium of body weight and the movement of limbs; or they may be evidenced cognitively through identification, recognition, or distinction.

2. Patterning: Arrangement and use of body parts in successive and harmonious ways to achieve a movement pattern or skill. This process is dependent on recall and performance of a movement previously demonstrated or experienced.

B. Ordinative Movement: The processes of organizing, refining, and performing skillful movement. The processes involved are directed toward the organization of perceptual-motor abilities with a view to solving particular movement tasks or requirements.

3. Adapting: Modification of a patterned movement to meet externally imposed task demands. This would include modification of a particular movement to perform it under different conditions.

4. Refining: Acquisition of smooth, efficient control in performing a movement pattern or skill by mastery of spatial and temporal relations. This process deals with the achievement of precision in motor performance and habituation of performance under more complex conditions.

C. Creative Movement: Those motor performances which include the processes of inventing or creating movement which will serve the personal (individual) purposes of the learner. The processes employed are directed toward discovery, integration, abstraction, idealization, emotional objectification and composition.

5. Varying: Invention or construction of personally unique options in motor performance. These options are limited to different ways of performing specific movement; they are of an immediate situational nature and lack any predetermined movement behavior which has been externally imposed on the mover.

6. Improvising: Extemporaneous origination or initiation of personally novel movement or combination of movement. The processes involved may be stimulated by a situation externally structured, although conscious planning on the part of the performer is not usually required.

7. Composing: Combination of learned movement into personally unique motor designs or the invention of movement patterns new to the performer. The performer creates a motor response in terms of a personal interpretation of the movement situation.

*Developed primarily through group study from 1970 through 1976 with the leadership of Ann E. Jewett, University of Wisconsin, Madison, and University of Georgia, Athens. Major contributors: Iris Bliss, Donald K. Brault, Gretchen A. Brockmeyer, Peggy A. Chapman, Sheryl L. Gotts, Wilma A. Harrington, Laura J. Huelster, L. Sue Jones, Sandra M. Knox, Douglas F. Knox, Marilyn J. LaPlante, Marie R. Mullan, Alison Poe, Sarah M. Robinson, Gail Royce, Lee Smith, Charles L. Wuerpel.

Ann E. Jewett and Marie R. Mullan, Curriculum Design. Washington, D.C., AAHPERD, 1977, pp. 9-10.

different situational demands as well as that of the (4) refining of the movement in a spatially and temporally organized manner are evident. Finally, the creative movement category is reached in which personalized characteristics of movement become visible and integrated. The performers begin to demonstrate the qualities of (5) varying, (6) improvising and (7) composing of movements in complex situations.

It has been suggested (Sinclair, 1983) that integration of these categories with other stage theory (theories) would be useful to provide guidance for teachers and learners to identify current levels of performance and plan an effective learning environment in order to obtain the optimal development for the skill acquisition.

2.3.3. Anderson (1982): Three stages of skill acquisition

Anderson proposes three stages of skill acquisition, which were adapted from Fitts'(1964) three stage model of skill acquisition. Fitts identified the cognitive, associative and autonomous stages with respect to the sequential processes of skill development. Anderson developed his theory of skill acquisition for ACT which was developed as a computer program.

> The ACT theory is basically organized for problem solving in the belief that problem solving is the basic mode of cognition. Consequently, the ACT system is organized in a hierarchical, goal structured manner, with both performance and the various learning mechanisms operating under the control of some goal or subgoal" (Shuell,1986; p.422).

In the discussion of Anderson's three stages in the ACT theory, it is essential to understand the two different types of knowledge involved, that

is, "declarative knowledge" and "procedural knowledge" as well as the mechanics of "production rules and systems". Please refer to section 2.1. (Knowledge Structure in Skill Acquisition) for the details of these terms.

Corresponding to Fitts' cognitive stage, Anderson presents the initial stage as "declarative stage" in which facts about the skills are encoded and interpreted to filter out faulty new knowledge. During this stage, verbal mediation is frequently observed.

> New information should enter in declarative form because one can encode information declaratively without committing control to it and because one can be circumspect about the behavioral implications of declarative knowledge. (Anderson, 1982; p.381)

> Interpreting knowledge in declarative form has the advantage of flexibility, but it also has serious costs in terms of time and working memory space. The process is slow because interpretation requires retrieval of declarative information from long-term memory and because the individual production steps of an interpreter are small in order to achieve generality. (Anderson, 1982; p.381)

The second stage, corresponding to the Fitts's associative stage, is the "knowledge compilation stage" in which knowledge is being transformed from the declarative form to the procedural form. During this knowledge compilation stage, errors are gradually detected and eliminated, therefore, efficiency is increased in performance. There are two subprocesses in this stage: one is "composition" and the other is "proceduralization".

Composition "takes sequences of productions that follow each other in solving a particular problem and collapses them into a single production that has the effect of the sequence" (Anderson,1982; p.382-383). This mechanism "reduces the number of production applications to perform the task" (Anderson, 1982; p.383). However, the important issue is that of how many small productions can be combined to form a large one. "All

the information in the production's condition must be active in working memory for the production to apply" (Anderson, 1982, p.384). The following is a simple example of applying Anderson's principle of composition mechanism to the tennis situation.

Single production rules

P1 IF the goal is to hit the ball with my forehand groundstroke,
THEN hold the racquet with the eastern forehand grip.

P2 IF the goal is to hit the ball with my forehand groundstroke, and I have just held the racquet with the eastern forehand grip,
THEN turn my body to my right side.

And so on.

Composition (P1 & P2)

IF the goal is to hit the ball with my forehand ground stroke and hold the racquet with my eastern forehand grip at first and then turn my body to my right side,
THEN hold the racquet with my forehand and then turn my body to my right side.

The second process, proceduralization is explained by Anderson (1982) as:

> (Proceduralization) builds versions of the productions that no longer require the domain-specific declarative information to be retrieved into working memory. Rather, the essential products of these retrieval operations are built into the new productions.(p.383).
>
> Proceduralization eliminates clauses in the condition of a production that require information to be retrieved from long-term memory and held in working memory (p. 383).

Using the previous examples, proceduralization mechanism can be demonstrated as:

Proceduralization

IF the goal is to hit the ball with my forehand groundstroke,
THEN hold the racquet with my forehand and then turn my body to my right side.

Therefore, during this knowledge compilation stage, proceduralization reduces the load on working memory and the composition of many steps into one produces the "speed up", and leads to a unitary rather than a piecemeal application.

The final stage, which corresponds to the autonomous stage of Fitts's theory, is the "procedural stage". In this stage, tuning of knowledge is taking place and proceduralization is further refined. "Tuning" refers to "the increasing appropriateness of the procedures" (Anderson, 1985;p.235). The improvement on speed and accuracy as a result the repeated practice is recognized because the learner selects the problem space more accurately. There are three mechanisms which are important features as the basis of tuning: generalization, discrimination and strengthening.

In the generalization process, process transfer is facilitated and the applicability of production rules becomes broader.

> The basic function of the ACT generalization process is to extract from different special productions what they have in common. These common aspects are embodied in a production what will apply in new situations where original special productions do not apply. Thus, the claim for the ACT generalization mechanism is that transfer is facilitated if the same components are taught in two procedures so generalization can occur (Anderson, 1982, p. 391).

On the other hand, in the discrimination process, the applicability of production rules becomes narrower. "This discrimination process tries to restrict the range of application of productions to just the appropriate

circumstances" (Anderson, 1982; p.392). There are two types of discriminations: "Action discrimination" which involves learning a new action, and it occurs only when feedback is obtained about the correct action for the situation. "Condition discrimination" involves restricting the condition when the ACT receives feedback that the old action is incorrect.

The strengthening process implies that some wrong productions are eliminated and better productions are strengthened. Because the generalization and discrimination processes are viewed as the inductive components of the learning system, "sometimes generalization and discrimination will err and produce incorrect productions. There are possibilities for overgeneralization and useless discrimination" (Anderson, 1982; p.394). Strengthening mechanism is, therefore, needed to eliminate inductive failures (i.e., wrong productions).

2.3.4. National Tennis Rating Program

The National Tennis Rating Program (NTRP) was developed in 1979 jointly by the USTA (The United State Tennis Association), USPTA(the United State Professional Tennis Association) and NTA (National Tennis Association).

> Their hope was to establish a universally acceptable rating program that would be free, easy to understand, and available to everyone. With the number of tennis players growing rapidly, it was felt that a consistent, nationally used rating system was necessary to insure continued growth and satisfaction in the sport. (USPTA, 1984; p.103).

The NTRP has two forms of categorization. One is the NTRP general rating categories (Appendix 1); the other is the Professional

Verification Guideline (see details in USPTA, 1984; p. 106-107)) which describes the more specific requirements of performance in each rating category.

The NTRP rating ranges from 1.0 (beginners) to 7.0 (world top players). The NTRP can be used for the objective and qualitative evaluation of performance by the players themselves as a self-rating criteria, as well as by the instructors. Moreover, the professional Verification Guideline (PVG) can provide the players and the instructors with technically specific and sequentially ordered guidelines to progressive instruction. For example, a player may have a general NTRP rating of 3.0, but has a 2.0 rating for his backhand stroke by PVG. The instructional focus should then be on the improvement of his backhand stroke besides looking ahead toward the requirement of 3.5 level. The NTRP is thus useful in assisting the instructor in making his/her plan: to identify the players level; to plan the activity schedules in accordance with the sequential development, and to set the objectives.

3. METHOD AND PROCEDURES

The aim of this study was to explore novice tennis players' thoughts while they are actually playing tennis games. A multiple case study method was adopted to permit an in-depth exploration of the novice players' thoughts. A qualitative approach based on the stimulated recall interview and a quantitative approach utilizing the CompuTennis score sheets to analyze the performance outcome were the major sources of the data collection. Additionally, field notes and two questionnaires were used as support data in an effort to explore the players as whole.

Yin (1989) advises that "The case study investigator must have a methodological versatility" and must "assure quality control" during the data collection (p.103) Thus, mutually complementary collection and cross-checking of data and analysis were employed in the attempt to meet the criteria of the multiple case study design. Qualitative researchers also advise the need for the "triangulation" of data sources and analysis (Goetz & LeCompte, 1984; McMillan, & Schumacher, 1989; Yin, 1989)). Triangulation "is the cross-validation among data sources, data collection strategies, time periods, and theoretical schemes" (McMillan & Schumacher, 1989; p.418). "It enhances the scope, density, and clarity of constructs developed during the course of the investigation" (Goetz & LeCompte, 1984; p.11) and it also assists in correcting biases if the researcher is the only observer of the phenomenon in the study (Goetz & LeCompte, 1984; McMillan & Schumacher, 1989).

Figure 3a presents an overview of the research procedure used in this study. Figure 3b presents single-case data collection, analysis and report part of Figure 3a in detail.

Figure 3a. Procedures of Multiple-Case Study Method

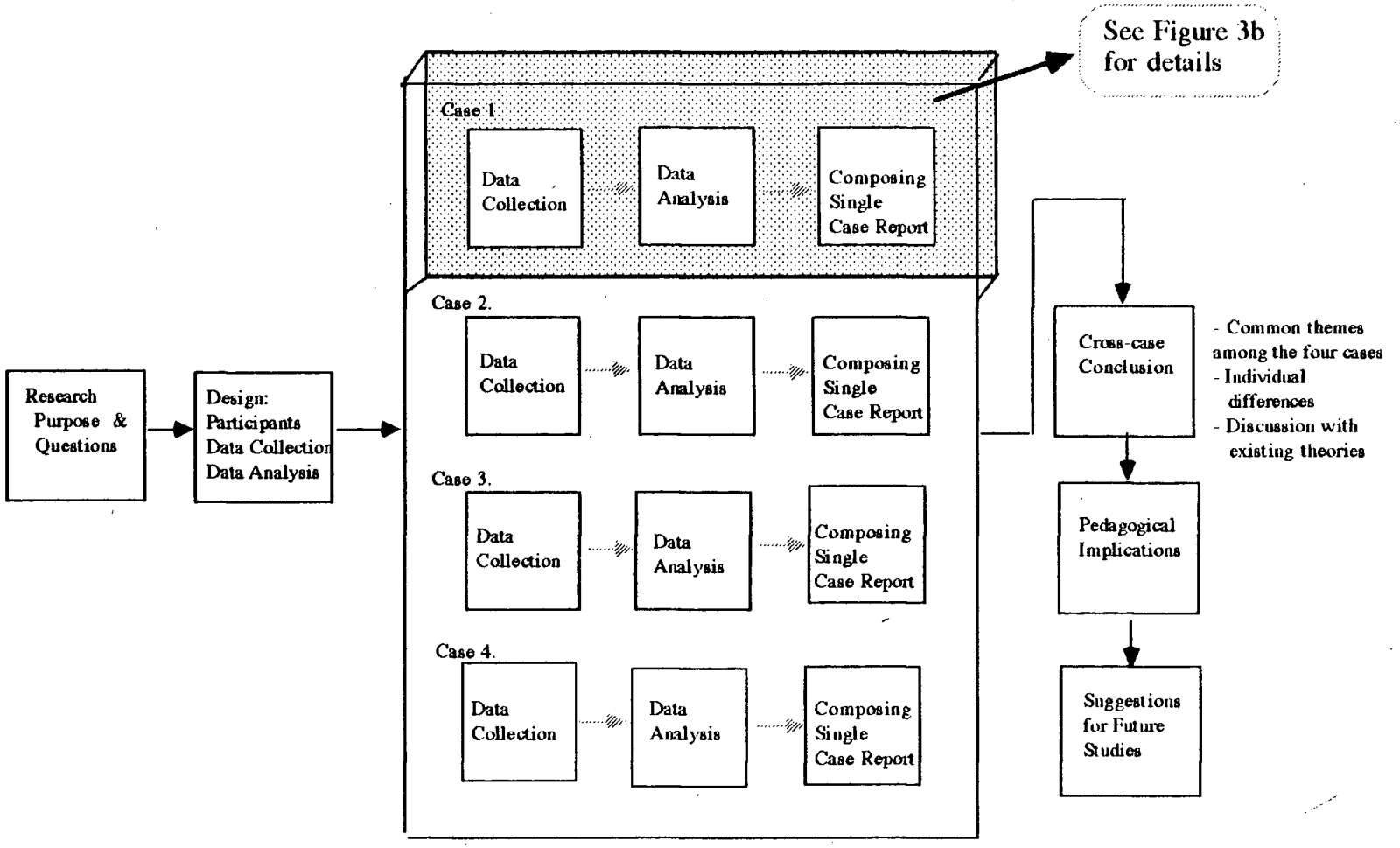
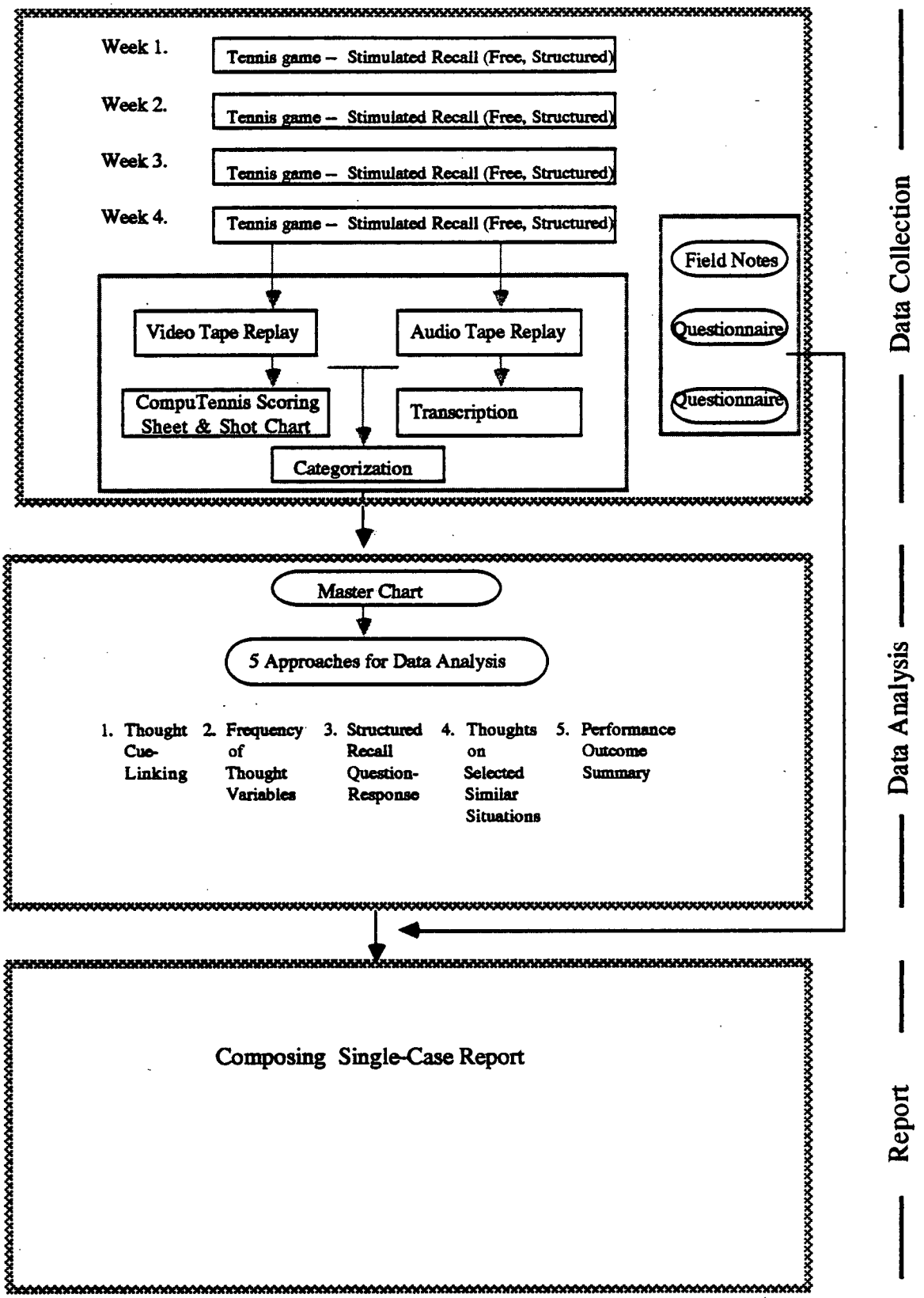


Figure 3b.
Details of Single-Case Data Collection, Analysis and Report in Figure 3a.



3.1. Qualitative and Quantitative Procedures

Quantitative research procedures have been incapable of providing any great insight in the exploration of thought processes and the understanding of the development of knowledge structures associated with human motor performance . Consequently, as the purpose of the study was to "... enter the world of the participant as it exists and obtain data without any deliberate intervention to alter the setting" (Locke, Spirduso & Silverman, 1987), a qualitative research paradigm (e.g., Clark & Peterson,1986; Goetz & LeCompte, 1984; Glaser & Strauss, 1967; Grimmett, 1982; McMillan & Schumacher, 1989; Locke, Spirduso & Silverman, 1987) was designed. .

As in all formats for qualitative study, detailed descriptions of context and what the participants say and do formed the basis for this inductive form of analysis. The focus of attention was on the perceptions of the subjects. What they said that they were thinking, the feelings they expressed and the explanations they gave were treated as significant realities.

> Qualitative paradigm is... believed to appeal to those who assume that reality is ever changing, that knowledge consists of understanding, and that research goals should examine processes. (Goetz & LeCompte, 1984; p.50)

Therefore, qualitative methodology formed the major part of the focus on the data collection and analysis; however, quantitative data was collected to supplement and complete the data collection processes. That is, quantitative data collection and analysis pertaining to the players' performance processes and outcomes (e.g., how the players start and end a

point: how the players keep the rally going during a point). It was considered to be essential to link thoughts with performance throughout as one's action, the thought processes and the development of knowledge are inseparable as they interact during the game situation (Newell & Barclay, 1982; Allard & Burnett, 1985). The players' actual performance was recorded on the "CompuTennis score sheets" (Appendix 2) and charted in the supplemental "Shot chart" (Appendix 3). These tools were very useful in relating the performance to confirm what actually happened or was happening when a player reported a particular thought at that point during the game.

Glaser and Strauss (1967) comment on the supplementary contributions of these methodologies:

> .... there is no fundamental clash between the purposes and capacities of qualitative and quantitative methods or data. What clash there is concerns the primacy of emphasis on verification or generation of theory .... (p.17).
> *In many instances, both forms of data are necessary* -- not quantitative used to test qualitative, but both used as supplements, as mutual verification and, most important for us, as different forms of data on the same subject, which, when compared, will each generate theory (p.18).

Similarly, Goetz and LeCompte (1984) comment on the pointlessness of a discussion of the dichotomous choice of objective and subjective data collection: they feel that discussion on the design of the method (i.e., whether qualitative or quantitative; generative or verificative) is not necessary: many researchers include the data collected from both objective and subjective methods.

3.2. Multiple Case Studies

This study employed the multiple case study methodology, as the focus was on intensive, in-depth examination of a few participants in the tennis game situation. This method was chosen because it was felt that intensive data associated with fewer participants would, in all probability, reveal greater insight (Goetz & LeCompte, 1984; McMillan & Schumacher, 1989) into existing thought processes and knowledge structures pertaining to novice tennis players .

Yin (1989) identifies the advantage of a case study strategy in some situations compared with other research strategies such as the experiment, survey, history and archival analysis strategies. The case study is best employed when:

> • A "how " or "why" question is being asked about a contemporary set of events, over which the investigator has little or no control (p. 20).

Moreover, Yin (1989) describes the definition of the technical features of case study strategy:

> *A case study is an empirical inquiry that*:
> • investigates a contemporary phenomenon within its real-life c ontext: when
> • the boundaries between phenomenon and context are not clearly evident; and
> • multiple sources of evidence are used (p.23).

In light of the purpose of this study, in which the importance of multiple sources of data and evidence was paramount, the use of a case study was deemed to be the most appropriate method to employ.

In comparison with the single case study design, the multiple case study design has various advantages under certain circumstances. "The

evidence from multiple cases is often considered more compelling, and the overall study is therefore regarded as being more robust" (Yin, 1989; p.52).

Furthermore, Yin (1989) notes that multiple case designs should follow a replication logic:

> Any use of multiple-case designs should follow a replication, not a sampling, logic, and an investigator must choose each case carefully. The cases should serve in a manner similar to multiple experiments, with similar results (a literal replication) or contrary results (a theoretical replication) predicted explicitly at the outset of the investigation (Yin, 1989).

In consideration of this replication logic, as Figure 3a illustrates, the present study followed the procedure in which each single case study was completed as a whole study. Then a cross-case analysis followed: the four novice players' thought processes and knowledge structures derived from the stimulated recall were compared and contrasted. Similarity and differences across the cases were investigated, and the cross case conclusions were discussed.

3.3. Stimulated Recall

Researchers who focus on the "thought process" associated with behavior depend heavily on various techniques of "self-report". In the field of education, this method has been used to examine teacher's thought process (e.g., Clark & Peterson, 1981, Housner & Griffey, 1985) and students' thought process (e.g., Peterson et al, 1982). Although Nisbett and

Wilson (1977) comment that verbal reports sometimes do not present accurate thought process, Ericsson and Simon (1980, 1984) argue that:

> verbal reports elicited with care and interpreted with full understanding of the circumstances under which they were obtained are valuable and thoroughly reliable source of information about cognitive process." (1980; P.247)

Among the "self-report" techniques, the stimulated recall method was employed in this study. Stimulated recall is a method used to assist disclosure of one's thought process by replaying a video tape or/and audio tape to facilitate participant's recall. The interviewer's role is to facilitate this disclosure. The stimulated recall technique is valid, as Bloom(1953) comments in his study, if the recall of covert cognitive behavior is done within 48 hours.

Tuckwell (1980) presents two practical considerations as well as precise technical points related to conducting the stimulated recall. The first practical consideration is that of "rapport" between researcher and the participants:

> In order to maximize the completeness with which the subject will report his thoughts, the researcher must take positive measures to establish rapport based on communicated authenticity, regarding for the other person and empathy (P.6).

The second point is "familiarization" of the subjects with the stimulated recall situation. The participants must familiarize themselves with the researcher and the equipment (i.e., video tape and audio tape recorders, microphone and audio monitor TV). Moreover, the participants must become accustomed to the routine of seeing themselves on the video monitor screen.

Tuckwell (1980) gives advice with regard to technical points related to the preparation of the equipment, competence with the equipment, videotaping techniques, stimulated recall interview techniques and transcribing techniques. These recommendations were all very useful in the present study in order to maximize the completeness of recording of the participants' verbal reports and tennis game performance.

There are variations as to the specific procedures which could have been used to conduct this stimulated recall process (Clark & Peterson, 1986). This study utilized the following two methods which were applied during each recall session:

1. Free recall ---Upon completion of the video taping of the actual performance, the participants viewed their play and controlled the stop and restart of the video tape at will to describe self selected incidents. The interviewer asked the open questions such as:

    What were you thinking?
    What were you trying to do at this segment?

2. Structured recall --- After the free recall, the tape was rewound. This time the interviewer controlled the video tape replay and posed planned questions to further probe the structure of the participants thoughts such as:

    a. Do you recall any aspect of this situation?
    b. Were you thinking about your technique?
    c. Were you thinking about your shot selection?
    d. Were you aware of your position?
    e. Were you aware of your opponent's shot selection?
    f. Were you aware of your opponent's position?
    g. Did you give any thought to the idea of what you should have done?

3.4. Pilot Study: Stimulated recall design and techniques

Stimulated recall method was chosen in order to collect the data to explore novice players' thought processes during the singles tennis games.

During the pilot study, some pertinent points were noticed which affected the eventual design and the procedure of this study.

a) The performance for the stimulated recall was decided to be approximately 3 minutes in duration after four sessions of pilot studies of stimulated recall interviews. Different durations of the tennis games ranging from 3 minutes to 15 minutes were video taped and the stimulated recalls were conducted. The longer the performance session, the more difficulty the players reported in the recall of what they felt and thought during the game. In the three minutes session, approximately six to eight points of the games were played.

b) Participants commented, when the interview was given while viewing their performance, that not much thought could be recalled just at the start of the game because (1) they were too busy "just getting into the game", and also (2) their recall of their thoughts was not clear. Therefore, it was decided that although they would play tennis game for five minutes and with the entire performance video taped, the free recall and structured recall segments of video replay would be administered two minutes after the start of a game to allow the participants to settle down and "focus " on the game, thereby permitting an interview covering a three minute taping that would have their complete attention.

c) The players reported that they could remember their thoughts more accurately if the interview was conducted immediately after a tennis game rather than permitting an interval of time to elapse between the

performance and the recall. Therefore, the stimulated recall of this study was scheduled to be conducted immediately after the conclusion of their five minute game.

d) During the first stage of the pilot study, the game was played in a format which involved novice-against-novice players and the interview was also conducted afterwards with both players at the same time. However, it was found that often one player dominated the interview while the other player did not comment on his/her thoughts very much. Moreover, often one player showed reluctance at expressing his/her thoughts in front of the other player. Therefore, the interview plan was re-designed to deal with each individual in a quiet and private location to facilitate freer recall of thought for all participants. Actually. Tuckwell (1980) comments on this point in his study, stating that stimulated recall sessions should be held in a quiet location free from interruption because the interviewees should be relaxed and feel free to recall and report their most private thoughts.

e) It was found that in the novice-against-novice game situation, usually there was not much substantive continuation of play (i.e., no prolonged rallying). A point often ended by the service or service return only. An arrangement was,therefore, made such that an intermediate level tennis player (3.5 level within the National Tennis Rating Program) would be engaged for the duration of the study to provide consistent and controlled opposition for all participants. This intermediate opponent was asked by the researcher to keep the ball in play by making the subjects move around the court. All the verbal reports taken and analyzed in this study were from games played under this revised arrangement.

f) It was also found that there appeared to be a difference in the players' thought processes depending on whether he/she was the server or the

receiver. Therefore, in the actual study, one participant played a five minute
game as the server, then recalled his/her thought; and then, he/she went back to the tennis court and play another five minute game as the receiver.
g) In addition to seeking the best way to conduct the stimulated recall, standardized interview techniques were also examined. The problem of "leading questions" was identified after the transcription of pilot interviews and revision of the question schedule was completed.

The design and the procedure of stimulated recall methodology for the actual research is presented in Figure 4. This procedure was followed four times (once a week) for all subjects.

3.5. Participants of This Study

The four participants of this study were volunteers from the PHED 226, an introductory tennis performance class in the program leading to the degree of Bachelor of Physical Education (B.P.E.) in the School of Physical Education of the University of British Columbia. Four volunteers were found, whose tennis experience, prior to enrollment in this tennis class, was zero to 15 incidents of participation. In addition, it was decided that the performance level of the volunteers should not be higher than 1.0 scale according to the National Tennis Rating Program (USPTA,1984, see Appendix 1a, b) as evaluated by the instructor at the beginning of the session. No subject was to have had previous tennis instruction. The Physical Education 226 class consisted of 1.5 hours of instruction, twice per week over a 14 week period and the performance level of all the

Figure 4.

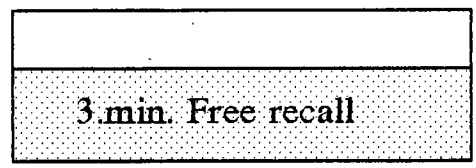
The Design and Procedure of Stimulated Recall

1. Player A as the server

(1)

5 minute game
Video taping

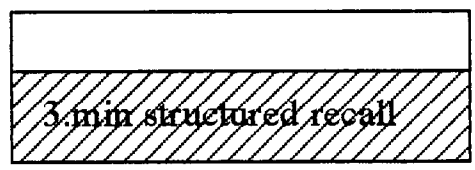
(2)



Video tape replay

Free recall (audio taped)
The player controls the video tape and makes self-selected comments.

(3)



Video tape replay

Structured recall (audio taped)
The interviewer controls the video tape and presents structured questions.

2. Player A as the receiver

The same procedure as outlined above (1), (2) and (3).

students in this course ranged from 1.0 to 3.5 according to the National Tennis Rating Program scale.

This study was conducted during the last four weeks of the course, that is, after the students had received eight weeks of instruction in the basic tennis techniques and tactics. The game component of the class began during the ninth week of the session.

The subjects were made fully aware of the purpose, time requirement and procedures of this study before they agreed to participate.

3.6. Multiple Data Sources

The following six data sources were selected as multiple data sources of this study: (1) Video taping of tennis game performance for stimulated recall, (2) Audio taping for stimulated recall, (3) Scoring performance in the CompuTennis system, (4) The Participant Background Questionnaire, (5) Field notes, (6) Thought and Performance Development Questionnaire.

3.6.1. Video taping of tennis game performance and replaying for stimulated recall.

The equipment used for recording of this data source was a video cassette camera with wide angle lens which was located at an elevated position at the rear of the indoor tennis court to permit the videotaping of the entire tennis court and the two players. The camera was also equipped with a time indicator in the lens. A video monitor and a video cassette recorder (VCR) were on site to enable replays. Upon the conclusion of the

five minute game session (please refer to the Figure 4 which presents the procedure of the games), the subject was seated in front of the video monitor and VCR for the stimulated recall procedure. The video monitor and the VCR were set up in a protected booth adjacent to the tennis court to provide a reasonably quiet and secluded atmosphere for the interview procedures. The VCR had a remote control panel which permitted the participants and the interviewer to control the operation of the tape during the stimulated recall. .

3.6.2. Audio taping for stimulated recall

The total interview process consisted of one in which the dialogue of the thoughts which the participants expressed during recall, as well as all the comments and the questions presented by the interviewer, were audio taped. The audio tape was running continuously during the free recall and structured recall session. These verbal reports recorded on audio tape were transcribed for data analysis.. The accuracy of the transcription was examined by two examiners. The audio tape was transcribed by the researcher of this study and a colleague was engaged to check the tape again to verify the accuracy of the transcription.

3.6.3. CompuTennis scoring system

The CompuTennis system is used as a tool to record and analyze tennis performance at the courtside during the game. Relevant data of a game are entered into a specially programmed CompuTennis Score Board. When this data is fed into the computer, the latter will execute a

computation and print out the player's results, usually in frequency, percentage and ratio of achieved tasks, covering various aspects of tennis as applied to that particular game. Some examples of the statistics computed by the CompuTennis are: "frequency and percentages of the first serve in", "percentage of point won when the first serves were in (effectiveness of the first serves)", "frequency of unforced errors and winners", "point won when the player advanced to the net" and "overall winner and error ratio". This analysis has been widely developed not only for the club tennis players but also for professional circuit players and junior developmental programs.

However, in the present study, this score sheet (Appendix 2) was simply used to monitor a player's performance progression and served to check the relationship between the participants' subjective comments and their actual performance. It permitted the confirmation of the accuracy of the analysis regarding what had actually happened during the game while examining the dialogue reflecting the participants' related thought. Because this CompuTennis score sheet does not indicate the total action between the first shot (i.e., serve or receiving of the serve) and the last key shot (i.e., the play ending event), a supplementary "Shot chart" (Appendix 3) was designed to provide a record of the entire sequence of shots involved till the completion of any one point. This is another useful tool to verify what actually happened on the court when a player was expressing his/her thoughts about a particular situation. Used together, the "CompuTennis score sheet" and the "Shot chart" permitted the researcher to obtain a complete record of every point played.

3.6.4. Participant Background Questionnaire

The participants were asked to complete a questionnaire which provided information about their age, previous tennis experiences prior to this course, experiences in other sports, etc.

3.6.5. Field notes

After every stimulated recall session, relevant matters were recorded in the form of field notes, with regard to:

1. Problems and remarks about the technical operation of audio taping and video taping: e.g., arrangement with the equipment dispensary personnel; arrangement with the assistant who was in charge of video taping; problems of operation of audio and video t ape recorders.
2. Problems and remarks about the interviewing procedure: e.g., schedules of the subjects.
3. Impressions of the players' performance during the class and video taped performance.
4. Impressions of the players' verbal reports: e.g., their motivation or willingness to express their thoughts.

3.6.6. Thought and Performance Development Questionnaire

At the conclusion of the data collection phase of this study, the participants were presented with a questionnaire which inquired whether, in their opinion, there had been development of their thought processes and

tennis performance as a result of the use of the interview together with the video replay. This questionnaire is presented in Appendix 4.

3.7. Validity and Reliability of This Study

Various strategies were incorporated in the research design to maximize the quality and control of the study. Attention was given to construct validity, internal and external validity and reliability factors.

3.7.1. Construct validity

Yin (1989) identifies three procedures which are commonly employed to maintain the construct validity of case studies: (1) multiple source of evidence; (2) establishing a chain of evidence; (3) having the draft case study report reviewed by key informants.

In keeping with these procedures, multiple data collection methods were employed to ensure not only construct validity, but also the reliability of the data related to the four novice players. Yin (1989) emphasizes that "the most important advantage presented by using multiple sources of evidence is the development of converging lines of inquiry, a process of triangulation ....." (p.97).

Also, a chain of evidence from initial research question to the final conclusion was carefully maintained during the whole process of the study in order to report the "fact" of the multiple cases.

Finally, the draft of one of the case studies was reviewed by the subject to ensure the construct validity of this study.

3.7.2. Internal validity

Inasmuch as the present study was predominantly of an exploratory and descriptive nature rather than one involving causal consequence, the question of internal validity was not a dominant issue (Yin, 1989). On the other hand, to the extent that the subjects of case studies are interviewed, the possibility of the threat to internal validity in the form of researcher's intervention exists. Specifically, the problem of how to avoid posing "leading-questions" during the interview sessions was one of serious concern here. During the pilot study, the questions and interview procedures were checked to minimize possibility of leading questions. During the structured interview itself, the researcher was constantly on guard against asking leading questions.

3.7.3. External validity

In the case study method, it is not appropriate to generalize the findings. Goetz & LeCompte (1984), instead, identify terms such as "comparability" and "translatability" of the characteristics which take the place of generalization in qualitative studies. Clear statement of method and result of the case study will permit replication by other researchers. This replicability (Yin, 1989) across the group and the disciplines will enlarge the acceptability of findings of this study.

3.7.4. Reliability

The reliability of this study was maximized in light of the following consideration:

1) With respect to data and analysis: Versatility of the data collected on the players and the quality control and analysis of the data tend to strengthen the reliability.

2) With respect to the nature of the verbal report method: Verbal reports are reliable data if verbal reports are "elicited with care and interpreted with full understanding of the circumstances under which they were obtained" (Ericsson & Simon 1980, p. 247). In the present study, the stimulated recall interview was conducted just after the tennis game; therefore it increases the reliability of the verbal reports.

3.8. Delimitations

1. The participants of this study were all students in a university physical education tennis class.
2. They were all novice level tennis players but their skill background and level in other sports varied widely.
3. They all were volunteered as participants in this study.

3.9. Assumptions

1. It was assumed that players' verbal comments during the interview accurately reflected their thought processes.

2. It was assumed that players could vividly recall their thought with the aid of the video tape replay, particularly since the interview was undertaken immediately after the action session.

3.10. Limitations

The participants of this study were not randomly selected and the number of the participants were small (four students); therefore it will not be possible to generalize the finding of this research. However, the clear statement of the method and the result will increase the value of "comparability" and "translatability" of this study (Goetz & LeCompte, 1984).

3.11. Data Analysis

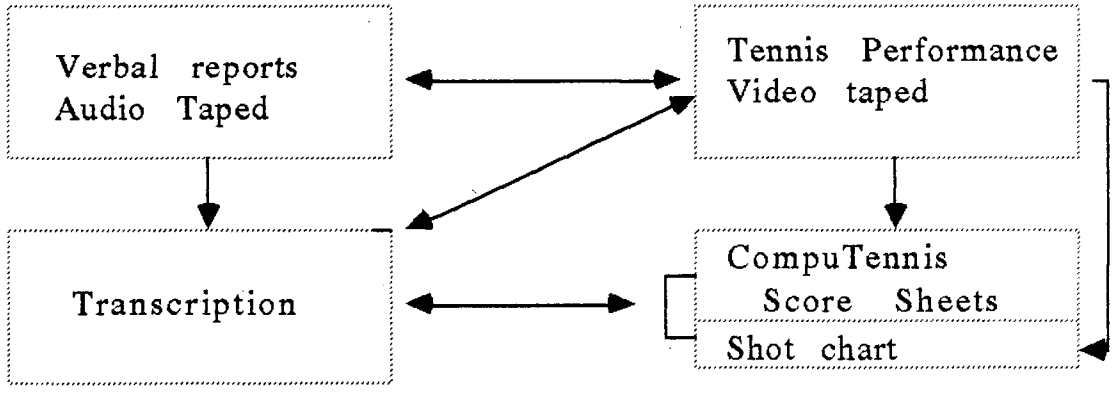
Data analysis commenced when the data was collected on the tennis court. As previously stated, the main data sources were the transcript from the audio tape, the video taped performance and the CompuTennis score sheets as well as the shot chart. The verbal reports were transcribed, analyzed and categorized. In order to explore all the sources of data pertaining to the tennis games played, master charts for each subject, which contained the performance outcome summary and categorized verbal reports of each game, were developed. Moreover, the verbal reports and performance were examined with five different approaches in order to ensure the complete and appropriate analysis of the data.

3.11.1. Transcription.

After a player's verbal report consisting of a free recall and structured recall of his/her own performance was audio taped, the dialogue in the report was transcribed for data analysis. In total, 240 pages of transcriptions for the four players were checked for accuracy by two monitors.

The transcript and the video tapes of the player's performance were then compared to determine the relationship between the dialogues and the taped performance which gave rise to the thought now transcribed in words. It was necessary to employ the cyclical mode of observation-analysis-observation-analysis (Griffin, 1984) to assure the accuracy of observation of performance and transcription. The transcription, CompuTennis score sheets and video taped performance were examined repeatedly to achieve a fine-tuning of the data analysis. Figure 5 shows the interactions between the verbal report and performance for the data analysis.

Figure 5. The interaction between verbal reports and performance



It should be emphasized that the data analysis of this study is inductive in nature. Therefore, the thoughts derived from the players' tennis performance were examined in the context of the totality of data gathered from various sources. The concept of triangulation of data collection and analysis (Goetz and LeCompte, 1984; McMillan & Schumacher, 1989) is, therefore, stressed in this study .

3.11.2 Categorization.

The pilot study permitted the issue of systematic categorization to be examined. Miles and Huberman (1984) list four important functions of pattern coding:

> 1) It *reduces* large amounts of data into a smaller number of analytic units.
>
> (2) It gets the researcher into *analysis during data collection* , so that later data collection can be more focused.
>
> (3) It helps the researcher to build a *cognitive map,* an evolving schema for understanding what is happening locally.
>
> (4) When several researchers are engaged in individual case study work, it *lays the groundwork for cross-site analysis* by surfacing common themes and causal processes. (p. 68)

The basic coding was categorized and the process resulted in the categorization of the data into six items based on the components of the tennis performance:

(1) Psychological aspects, (2) shot selection, (3) shot execution, (4) position and movement, (5) technique, (6) others. The use of this classification of

items was based on a careful examination of the patterns of verbal reports and on the result of the task analysis of the tennis performance in a previous study (Oguchi-Chen, 1986) and other tennis instruction literatures (e. g., USPTA, 1984).

(1). Psychological aspects included comments on emotional control (arousal level and thought control such as positive and negative self-talk and feeling), and attention control (concentration, attention or focus and visualization or mental practice).

(2). Shot selection included comments related to a player's intention to hit a particular shot (e.g., the direction, depth, height, speed, spin of the ball which had been selected.). Also included in this category were the comments associated with their defensive and offensive intentions (e.g., "I was just trying to hit the ball into the service court.").

(3). Shot execution referred to comments relating to what a player did, regardless of whether or not the shot was executed as he/she had intended. In this category, the comments were often of the kind such as:"The ball lands on the line."; "I did get it in the court."

(4). Position and movement were simply the verbal report indicating awareness of where the player and/or the opponent took up his/her position and where he/she moved during the game.

(5). Technique referred to the comments relating to the way the players hit the ball, including their body and racquet movements.

(6). Others included off-task comments such as the thoughts which were totally unrelated to the present tennis game or those recalled

from the past experience. For example, "I remember that last week my serve was much better than today."

All the verbal reports were color coded according to the six categories defined above. This coding was the first step in examining and categorizing the players' thoughts as disclosed during the interview.

3.11.3. Development of Master Charts.

While the interview,transcripts and appropriate color codings were being prepared, a "master chart" was designed as a device which would permit the juxtaposition of all sources of data pertaining to a single tennis event for one subject. The master chart laid out, on one sheet, a summary of all the data pertaining to a single tennis event, typically each point played in a game. It associated all the "facts" about a point as recorded in the CompuTennis score sheet with the verbal reports on that point given by a player. This proved to be a very important instrument as it permitted the examination of each player's thoughts and knowledge structures as well as all the facts giving rise to such thoughts such as the details of his/her performance outcome. It was necessary to constantly refer to these interrelated facts to enable a clear picture of a player as a whole to emerge: the image of an actual, living player performing a tennis task while all the relevant information guiding his performance is being processed in his mind. This method of the master chart emanated from the description of meta-matrices of cross-site analysis by Miles and Huberman (1984) who state that:

> Meta-matrices are master charts assembling descriptive data from each of several sites in a standard format. The simplest form is a juxtaposition of all the single-site summarizing chart on one very large sheet or wall chart. The basic principle is *inclusion* of all relevant data."(p.152)

This master chart, in light of its expansive nature,only summarized the information from the CompuTennis score sheet for performance outcome. However, as to the remaining categories, especially the color coded verbal reports which were substantially important, these were transcribed verbatim onto the chart. In effect, for each player's daily tennis performance, four functions were presented on the master chart: two representing the free recall sessions, while the other two representing the structured recall sessions. Of the two free recall sessions, one corresponded to the player as the server, the other corresponded to him/her as the receiver. The two structured recall sessions were similarly divided.

Table 2 is presented as an example and shows only portion of a daily master chart for one player, that is, covering five of the 13 situations of her free recall session as the server.

The performance outcome/profile part of the chart lists 1) first serve, in or out; 2) second serve, in or out; 3) the duration of the rally (i.e., the number of times the ball was hit before a winner or a mishit terminated the rally); 4). the last shot, the kind of stroke (e.g. forehand ground stroke (FHGS) , backhand volley (BHVL), etc.); and 5) the result of the point: (i.e., won/lost). These items were included in the master chart because they appeared to be the events of which the players were especially conscious, as evidenced by their frequent reference to them in their recall sessions.

Table 2. An Example of Master Chart

Player: C.A. day 1, As a server, Ist Recall.

point	SV 1st	2	rally duration	last shot	result Colle	Dave	feeling	Feeling	Shot selection	Technique	Shot execution	Position	Others
general							+	Felt good when I was playing ⊛	I tried to hit it one side or the other ⊖ ④So I did not know if I lobbed it, he still got it, he could smash it, or if I hit it right at him, he'd just a sort of volley it back, a thousand of times.		⊛because I felt like I was hitting it better than other times. ⊖ or I miss hit it, hit it out	Lot of times he seems to be every where ④ I was trying to figure out if he was up or back, sometimes it's hard to tell he was just sort of in the middle ④	
1	X	0	6	BHGS		- F							
2	O		9	FHGS	- -								
3	O		8	FHGS		+ +							
4	O		3	FHGS	- F				I tried just flick it over the net ⊛			⊛ because I saw he was way back	
5	O		3	BHGS	- -				(SV) Just about trying to get it in. I didn't think about if I want to place to the right or left, ⊛				⊛ I just want to get it in, to start to get rally going. I can't get the point on the serve, so maybe I can get a point on the rally.
6 | 13													
total	12 13	1 1	77 x= 5.92		3 (1)	9							

The symbols and abbreviations are fully explained on the following page.

point general = The players comment(s) on the overall feeling and remarks about the game which he/she has just finished playing.

SV
- SV = serve
- O = service in
- X = service fault

last shot
- FHGS = forehand ground stroke
- BHGS = backhand ground stroke

result
- - F = forced error
- - - = unforced error
- + + = winner

total
- 12 = 12 first serves are in out of 13 occasions in this game.
- 13
- 77 = total duration of rallies in this game, in terms of the total combined number of hits by both players.
- x = mean (e.g., x=77 / 13 = 5.92)
- 3 = Colleen won 3 out of 13 points.
- 9 = Dave (the opponent) won 9 out of 13 point.
- (1) = uncertain result (i.e., visual observation differs from the verbal report.)

⊛ ⊖ ⊜ ⊚ = A complete sentence in the verbal report can be reconstructed by connecting two different remarks in two separate categories at the point marked by the same symbol.

These marks are sequential (i e., ⊛ marks both the end of the first remark and the beginning of the second remark; ⊖ marks both the end of the second remark and the beginning of the third remark, etc..)

Although the development of the master chart was very time-consuming, it proved to be an invaluable tool as it provided extensive, juxtaposed information at a glance. It was very useful to be able to observe a player represented as a whole player-person, with a variety of data sources gathered together on one sheet. The individualistic characteristics of a player are also detected at a glance. For example, the record revealed that some players made relatively frequent remarks in the column labelled "feeling", while another player was very frequent with remarks under the "shot selection" column. Also, it facilitated the monitoring of the thought processes of one player at any moment . For example, it was a simple matter to determine, at a glance, what thought had come into a player's mind after(or before) his/her serve was poorly executed.

3.11.4. Five Approaches of Data Analysis

During the long process of collecting the data, preparation of the transcription and the development of the master chart, it became apparent that there were various ways or approaches to analyzing the data. To ensure that the data collected would receive the most thorough examination and to be as free as possible from biases common to this type of research, it was decided that, rather than relying only on any one approach to the analysis, five different approaches would be used for the purpose of cross-checking or triangulation: (a) Thought cue-linking, (b) Frequency of thought variables,
(c) Structured recall question-response, (d) Thought on selected similar performance situations and (e) Performance outcome summary.

a) Approach 1. Thought cue-linking

Preparation of the master charts revealed that there were definite differences between the players' thoughts and selective attentions with regard to their internal and external focusing, that is, whether they were focusing on the external situation or on their own internal movement. Moreover, it appeared that the thought -cues in the external situation or internal movement seemed to link differently for different players (see Figures 6, 8,10, 12; these figures will be explained in the section 4: Single Case Studies). Thus, it was felt that cue-linking could be used as one basis for examining the different thought processes for the players.

The semantic nets of cognitive skills pertaining respectively to novices and experts were presented by Chi, Feltovich and Glaser (1984) in a case study of physics problem solving , and by Leinhardt and Smith (1985) in a case study of mathematics instruction. The purpose of their studies was to explore and contrast the knowledge content of novices and experts in a given field.

In the present study, the thought and attention cues were simply linked into a flow chart. The players' verbal reports of particular incidents were drawn as linkages in the diagrams to examine how the thought and the attention cues were associated. The verbal reports of tennis incidents were sorted into units of sentences and phrases which represented different aspects of thoughts and attention, and were color-coded in the linkage system to be consistent with the same categorical scheme that was used when transcribing the verbal reports. The color coding in the linkage system facilitated the detection of thought pattern differences in different players. It should be mentioned that it is the

voluntarily offered remarks portion of the verbal reports that are particularly examined and analyzed by this approach. One diagram was produced for the situation when the player was serving; a separate one was produced for the receiving situation; yet another one was created to represent the situations where a rally was taking place.

b) Approach 2. Frequency of thought variables

The second approach to the analysis of the performer's thoughts was simply to count the number of different variables contained in the verbal reports as recorded on the master charts. At a glance it was obvious that, for example, while one player focused more on his technical points, another player's thoughts were more situation oriented. The total number of thought variables represented in the reports varied among players. This approach has been utilized in other studies which have examined the thought processes of students who are learning mathematics in a classroom (Peterson et al., 1982) as well as thought processes of physical education teachers with regard to their planning and interaction in the classroom (Housner and Griffey, 1985).

This analysis was completed only for that portion of the report that dealt with the voluntary verbal report, mainly in the free recall session. However, those verbal reports collected during the structured recall session but were actually occasions when the players voluntarily talked about their thoughts without structured questioning were also included. In any one incident, (e.g., the play of one point in a tennis game), where a player's remarks contained a repetition of a thought which had already been

expressed about that point, the total of such repeated expressions will count only once for that variable for that incident.

In this analysis, the six general (color-coded) categories mentioned above were further divided into sub-categories which were labelled with respect to the information processing system of human performance. The examples are presented in Tables 3, 4, 5, and 6.

c) Approach 3. Structured recall question-response

During the second recall period (e.g., structured recall session), pre-planned structured questions were presented to the players. The questions were:

a. Do you recall any aspect of this situation?
b. Were you thinking about your technique?
c. Were you thinking about your shot selection ?
d. Were you aware of your position?
e. Were you aware of your opponent's shot selection?
f. Were you aware of your opponent's position?
g. Did you give any thought to the idea of what you should have done?

As it turned out, the administration of both the free recall and the structured recall sessions were occasionally modified somewhat from the intended structures. The modifications came about in the following ways:

(1). During the free recall session, some of the structured questions listed above were occasionally and unintentionally asked during the free recall segment of the interview.

Example: Player L.P., April 3.(day 3), Point 8, Free recall.

(L.=L.P. I.=Interviewer)

L. Here, this is when we started having a pretty good rally.
I. Good backhand.
L. So that one felt really good.
I. Uh-huh.
L. When, at this point, I could tell I was a little more relaxed, and I was stopping before I was hitting the ball? Like normally I'm still running when I'm hitting the ball, and it goes out of control. At that point, we were having a pretty good rally, and I felt pretty, pretty good.
I. Were you thinking something when you were rallying the ball? Where you want to hit kind of thing?
L. No, I wasn't because quite a few times I'd hit it to him and then, I'd realized, I thought like, "What am I doing!" like I should be trying to hit away from him. So I wasn't, before I was hitting it, I wasn't really thinking about where I was putting it.
I. Uh-huh.
L. Then I did because (I) realized.

(2). Not all the pre-planned questions were asked on all the points of play because: (i) sometimes the players would start talking about matters related to the pre-planned questions voluntarily while viewing the video, making the asking of pre-planned questions redundant; (ii) at other times, the situation being viewed on the video was of such a nature as to render the asking of the pre-planned questions inappropriate (e.g., very embarrassing for the player). For example, at the time when a player has just double faulted; or when he/she has just failed to keep a rally going, it did not make sense to ask whether he/she was aware of his/her or the opponent's position. So, under these circumstances, such a question.was not asked.

(3). During the third day of interviewing, two additional questions which were not among the five originally planned questions were put to the players. These two revised questions were also retained in the questioning of the fourth day. The added questions were:

(h). How soon could you anticipate or identify what kind of a shot was next coming to you from your opponent during a rally? (e.g., before the opponent hit the ball? before the ball crossed the net? after the ball crossed the net? after the ball bounced?)
(i). When did you make the decision as to what kind of a shot to hit during a rally?

The reason why these additional questions were included was that, while the player's movements responding to the on-coming ball was being observed, it was felt that it was extremely important to address the relationship between the player's unobservable perception skills, their decision making, and their performance outcome. Some of the players regularly commented on their late preparation to move toward the ball or to hit the ball. What caused this delay? Did the performance have something to do with the question of perception skill? Questions (h) and (i) were designed to find answers to this issue and help to reveal, more fully, the characteristics of a novice player in relation to his/her developing perception skills.

The responses to the structured questions were charted on large sheets. On one sheet, one player's responses to particular questions were recorded in four separate columns in accordance with the different days on which the remarks were made and recorded.

d) Approach 4. Thoughts on selected similar performance situations

The fourth approach used to explore the players' thoughts examined their verbal reports as they related to selected similar performance situations. In a similar performance situation, (e.g., when the opponent deliver an underspin shot), the ways in which the players reacted in their performance as well as their associated thoughts, as revealed during the interview, seemed to be different. One player seemed to perceive the opponent's underspin shot as a considerable problem whereas another player did not. In addition, the attention given by one player in a specific situation (e.g., the opponent's deep shot) appeared to be different from other players in a similar performance situation. Moreover, the way a player went about solving a problem, and the reasons he attributed to successful or unsuccessful performances also seemed to be different from the other players.

The studies by Leinhardt and Smith (1985), and by Chi, Feltovich and Glaser (1981) served as models for this approach. Their studies, which focused on the problem -solving processes and knowledge structures of novices and experts on the cognitive skills, utilized excellent tables and figures to compare the different problem-solving approaches. Also, the "Cross-Site Analysis" presented by Miles and Huberman (1984) served as a basis for this approach.

The video taped player's performance was observed especially for this approach. The following are the situations selected:

(Pertaining to the serve):

1. The player hit a good serve.
2. The player double-faulted.

(Pertaining to receiving the serve)

3. The player hit a good service return.
4. The player missed a service return.

(Pertaining to rallies)

5. The player could sustain a relatively long rally (i.e., at least six exchanges).
6. The player hit a good last shot.
7. The player came to the net position.
8. The opponent hit an underspin shot during a rally.
9. The opponent hit a deep shot.
10. The opponent hit a good drop shot..

e). Approach 5. Performance outcome summary

The process and outcome of each point was charted in the CompuTennis score sheet and then the important points related to the verbal report were transferred onto the master chart (please see Table 2) to contrast the verbal report with the performance situation. Furthermore, this performance outcome was summarized and presented in Table 3. This quantitative data was contrasted with the results of various approaches of data analysis.

Table 3. Performance Outcome Summary (Played as a server)

Players	L.P.				R.M.				S.T.				C.A.			
Days	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Played points in 5 min.	13	15	11	10	11	10	10	11	14	12	14	13	13	9	12	12
Serve: 1st SV in	8	9	6	3	6	3	6	4	6	6	9	7	12	4	9	6
2nd SV in	4	2	4	4	3	1	2	2	2	2	4	2	1	3	3	2
Double fault	1	4	1	3	2	6	2	5	6	4	1	4	0	2	0	4
Rally duration *: Total	56	44	53	39	41	24	49	36	34	31	40	43	77	63	61	34
Mean	4.3	2.93	4.82	3.9	3.73	2.4	4.9	3.27	2.43	2.58	2.86	3.31	5.92	7.0	5.08	2.83
Range	1-9	1-7	1-9	1-15	1-7	1-5	1-12	1-9	1-5	1-6	1-5	1-9	3-9	1-17	3-12	1-10
Point: won	2	2	1	1	6	1	4	1	3	3	1	2	3	3	3	3
lost	11	13	10	9	5	9	5	9	11	9	13	11	9	6	9	9
uncertain result **	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0

Played as a (receiver)

Players	L.P.				R.M.				S.T.				C.A.			
Days	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Played points in 5 min.	17	16	14	15	13	13	12	14	15	19	14	13	13	12	13	12
Serve***: 1st SV in	14	13	10	12	11	9	7	11	6	18	9	7	7	9	10	10
2nd SV in	1	3	1	3	2	4	4	2	8	1	4	5	2	3	2	2
Double fault	2	0	3	0	0	0	1	1	1	0	0	1	3	0	1	0
Return errors	7	6	4	7	6	5	3	5	7	11	4	8	5	3	6	4
Rally duration : Total	49	56	46	49	47	59	48	46	44	50	40	39	33	59	44	63
Mean	2.88	3.5	3.29	3.27	3.62	4.54	4.0	3.29	2.93	2.63	2.86	3.0	2.54	4.92	3.38	5.25
Range	1-6	1-8	1-10	1-7	1-10	1-13	1-12	1-7	1-9	1-4	1-5	1-8	1-5	1-11	1-8	1-15
Point: won	4	1	4	3	1	2	6	3	2	3	4	2	5	4	4	3
lost	13	15	10	12	12	11	6	11	12	16	10	11	8	8	9	9
uncertain result	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

Note *Rally duration: (1) Serve was counted one. (The 1st serve, the 2nd serve, in, out, double fault, ace).
(2) The last shot (in or out) is also counted one.

**Uncertain result means that visual observation differs from the verbal report.

***Served by the opponent.

4. SINGLE CASE REPORTS

Various perspectives were taken in carrying out the analysis for the purpose of gaining maximum understanding of the four players' thought processes and knowledge structures in relation to their tennis skills progression. During the process associated with the exploration of the data, it became evident that, in general, the four players all demonstrated their own idiosyncratic characteristics consistently throughout the four weeks.

This section presents each player's characteristics as revealed by a "descriptive-analytical interpretation" rather than a descriptive narration or a theoretical interpretation, to use the nomenclature given in the discussion of the three levels of abstraction commonly used in the analysis of data and presentation of findings associated with this type of investigation (McMillan and Schumacher, 1989). Descriptions of what the players thought and felt during the interview in relation to their tennis performance are presented and the players' thought processes and knowledge structures are analyzed and interpreted in relation to the complex internal and external cues reported in particular game situations.

It appeared that the players' thoughts contained in the verbal reports were mainly concerned with three areas of tennis performance: their serve, return of serve and rallies. Although as actions in a tennis game, the serve and return of serve should logically extend smoothly into rallies, these aspect of play generally seemed to form three separate entities in each player's thought processes. This maintenance of the three distinct identities (of serve, return of serve and rallies) appears to be a characteristic of the thought pattern of novice tennis players as opposed to more advanced level

players. Accordingly, the description of each of the case studies is, at first, presented in relation to these three distinct aspects. Then an interpretation and analysis are presented in a general summary of each case.

4.1 Case Study 1. Player C.A.

C.A. is a 21-year old student majoring in physical education. Before taking this tennis course, she professed to have never played tennis and was evaluated on her tennis skill level as 1.0 on the N.T.R.P. scale by the instructor. She has been very active athletically and reported eight years of soccer, three years of basketball and five years of track experiences. She aspires to be a physical education teacher upon graduation from the BPE program.

Her answers to the Thought and Performance Development Questionnaire (Appendix 4), administered at the end of the four week study, indicated that while participating in the study, her game analysis had become more active as the time progressed from the first week to the fourth week. Her answer to question #8, which was intended to determine the reasons for such increased analytical activity, indicated that although her tennis skill had improved during the four weeks of playing in much the same manner as she had experienced in learning any other sport activity, the viewing of video replay and the interview process seemed to have speeded up her progress. On the crucial issue of whether the increased thinking activity was due to viewing the video and having interviews or due to the fact that she had become a better tennis player, she indicated that the use of video had enabled her to see "what I did and I had to state why." She also stated that "recall

without video would be hard", implying that being able to see her performance also stimulated her thinking, which in turn helped to speed up her progress and improvement as a tennis player.

The following is a summary of C. A.'s verbal reports of her performance as interpreted from the transcript of her interview.

Serve

C.A. expressed a very limited number of thoughts regarding her service as compared with the other three players. In the games when she was the server, her attention was generally directed more to the rallies rather than to the serve. This is clear from the Frequency of Thought Variables Table (Table 4), which presents a record of the number of times a player reported thinking about specific performance-related cues. On the days (Day 1 and 3) when she was most successful in getting the serve in the service area (i.e., when she did not commit a double fault) her thoughts related to the serve were even less than during the other two days (days 2 and 4). Her reports indicated that she was primarily concerned about sustaining the forthcoming rally.

On the second day, her mind was set on progression of the serve as evidenced by her attempt in trying a different serve, the slice serve, because she felt that:

> C. I can hit harder with a bit of spin. If I put spin on it, I can get it in." (2/S/F/G * note 1)

---

note 1 The four-symbol notation in the brackets above identifies the location of the statement in the transcript. The first symbol indicates the specific date of occurrence: Days 1,2,3,4. The second symbol marks the player as the server (S) or the receiver (R). The third symbol distinguishes the free (F) and the structured (S) recall sessions. The last symbol refers to the particular point, 1,2,3,...14, to which the statement belongs, as well as general comments (G),if any, before the player starts to talk about each point of play.

Table 4.
Frequency of Thought Variables

Name __ C.A. __

SV= serve, RL= rally, TL= total
Number in O = negative remark

	day 1			day 2			day 3			day 4		
	SV	RL	TL	SV	RL	TL	SV	RL	TL	SV	RL	TL
1. Feeling												
Emotional cont'l-Arousal												
-Thought		2	2		1	1		2	2	(2)		(2)
Attention cont'l-Concent'n				(1)		(1)						
Mental practice												
2. Planning for today				1		1						
3. Input relevant cues												
the ball movement								2	2			
his movement & position		7	7	1	7	8		6	6		1	1
his shot selection		2	2		2	2		6	6		3	3
his shot execution		2	2					2	2		3	3
my movement & position		2	2					2	2			
anticipation		2	2		2	2						
4. Response selection												
in the court	1		1	2		2				3	1	4
direction	(1)	4	4(1)	1	5	6	1	1	2		2	2
depth		3	3		3	3		4	4		2	2
height		4	4					3	3		1	1
spin				3 (1)		3 (1)	2	1	3			
speed		(1)	(1)	1	2 (1)	3 (1)						
offensiveness		1	1								1	1
defensiveness (rally going)		1	1		1	1					1	1
strategies (shots ahead)					3	3		3	3		2	2
5. My response execution												
good		1	1	1	1	2		4	4		1	1
out/not intended		4	4	2 (1)	3	5 (1)		1	1	2	1	3
6. Analyzing												
my technique		1	1	3 (1)	1	4(1)	1	1	2	3 (1)		3 (1)
my shot selection					1	1					1	1
my level	1		1									
his level											1	1
7. Evaluating												
what I did (good, bad)		2	2		2	2		2	2	4	1	5
I did not know what to do		1	1					1	1		1	1
I could should) have --		2	2					1	1		1	1
He could have --		1	1									
8. General comment												
9. Off task thought												
	(1)	(1)	(2)	(4)	(1)	(5)				(3)		(3)
Total	2	42	44	15	34	49	4	42	46	12	24	36
performance results												
1st serve in	12/13			4/9			9/12			6/12		
2nd serve in	1/1			3/5			3/3			2/6		
Rallies: total/ x=	77 / x=5.92			63 / x=7.0			61 / x=5.08			34/ x=2.83		
won/lost	3/9 (1)*			3/6			3/9			3/9		

*Uncertain result.

C.A.'s comments on this experiment with a slice serve continued on the third day. When she was asked,

I. "What were you thinking?"
C. "Just that little bit of spin on it...Just that spin because then I can hit it harder, it seems." (3/S/F/7)

During the structured recall session on the third day, she was asked whether she thought about the technical aspects of her game:

C. Yeah, yeah. Serve, maybe not. Serve I might think a little bit about technique, because I still don't---, I don't have that proper back-scratch, and all that sort of stuff. I've got to think a whole lot about---. Just where I want to place it.
I. When you are playing an actual game, you don't think too much about your back-scratch position?
C. I just think about putting a little spin and getting it in. (3/S/S/11)

On the fourth day, she had trouble with her serve. She was correcting her serve and her thoughts appeared to focus on the technical point of how to hit the serves to get them in the service court. Except for the fourth day, her thoughts on her serve were related to the quality of the serve, such as executing a spin serve or guiding the serve in a specific direction.

C.A.'s other thoughts while she was serving, indicated that she was thinking ahead as to how to win the point in the ensuing rally from her opponent who was a higher level player (approximately at 3.5 level of the NTRP). On the first day, she stated her thoughts as to how she was planning to win the point, as the following transcript shows:

I. What were you thinking before the serve?

C. Just about trying to get it in, just about...I don't think about I want to place to the right or left; I just wanted to get it in, to start to get rally going, almost. I can't get the point on the serve, so maybe I can get a point on the rally. (1/S/F/5 or 6)

The thought of how to win the point was also expressed in her thoughts on rallies, which will be discussed later in the "Rally" situation..

In summary, her thoughts expressed on the serve itself were not as frequent as compared with her preoccupation with the rallies. Most of the time she could get the serve into the service court, and was primarily experimenting with some different qualities on the serve.

Return of Serve

With respect to her thoughts at the time of preparing to return the serve, C.A. reported that she could predict or anticipate what kind of serve her opponent was going to deliver and that she was also dealing with the problem of returning the opponent's high bouncing spin serve. She found that:

(1). C. With that spin, I noticed that if you barely hit it, it goes deep. With that spin that he hits it with, and I tried to hit it a bit harder, and it went way out. Even that one; I just let it hit my racquet, and [it] goes all the way to the baseline. (2/R/F/7)

(2). C. Because if I put anything behind it after his serve, it would just go flying, but if I just let it hit my racquet, it'd go all the way to the baseline. (2/R/F/7)

Responses similar to (1) and (2) above were also made on days three and four, with regard to coping with the problem of the high-bouncing spin serve.

Generally, her thoughts on the service return were related to the quality of the opponent's serves (e.g., direction, spin and depth of the serves) and to the decision of where to return the serve in relation to the opponent's position. Typical responses on the service return were:

(3) C. That one was in. (The situation: The opponent hit the first serve from the deuce court and Colleen's forehand return of the serve went down the line and this shot became a winner.)
I. What were you thinking?
C. I was trying to hit towards the line, down the line. Again it happened just a bit long.
I. So you are aiming in that direction?
C. Yeah, I always go down there (I. Yeah, good) to pull under that side after he serves it. (2/R/S/11)

(4). I. When did you decide on that direction?
C. I can return the serves always there because he serves from the top corner. He serves from that side, or he serves from right over there. So when he hits it to me, I might as well just go, hit opposite, then I 'm not setting him up for that.
I. After the ball bounces or before...?
C. Before even he serves it.
I.. Oh, oh.
C. Because he is way over in the left side, I can go back because he's standing in the corner.
I. O.K.
C. Like he serves from there, right? He serves from there, so I mean right now I know where he is going to hit it, hit it down the line. (3/S/S/13)

Responses similar to (3) and (4) were also observed on Day 4.

In summary, she was successful in identifying the characteristics of the opponents' serve (e.g., the opponent's serving position, the quality of his serve, etc.) and tried to solve any problems related to the serve. Her main response to cope with the opponent's serve was to return the serve to the opposite corner from where the opponent was standing. This preferred

return of serve seemed to be a result of her thinking that by so doing she could place herself in an advantageous position for the ensuing rally.

Rallies

There were only very few occasions that she voluntarily expressed her thoughts related to stroke techniques during a rally. Her focus was almost always upon the situational cues: her own and her opponent's position and movement were always reported as a functional relationship which linked her thoughts and action to the opponent's selection of shots. Figure 6 shows an example of the characteristics of her thought cue-linking in the rally situation of the third day. The situational cues relating to herself and those relating to her opponent appeared to alternately occupy her attention. Actually she talked about her opponent's cues (i.e., external cue) even more than her own cues (i.e., internal cue).

On the same day, her thoughts demonstrated evidence of alternative shot selections depending on the opponent's position and action. .

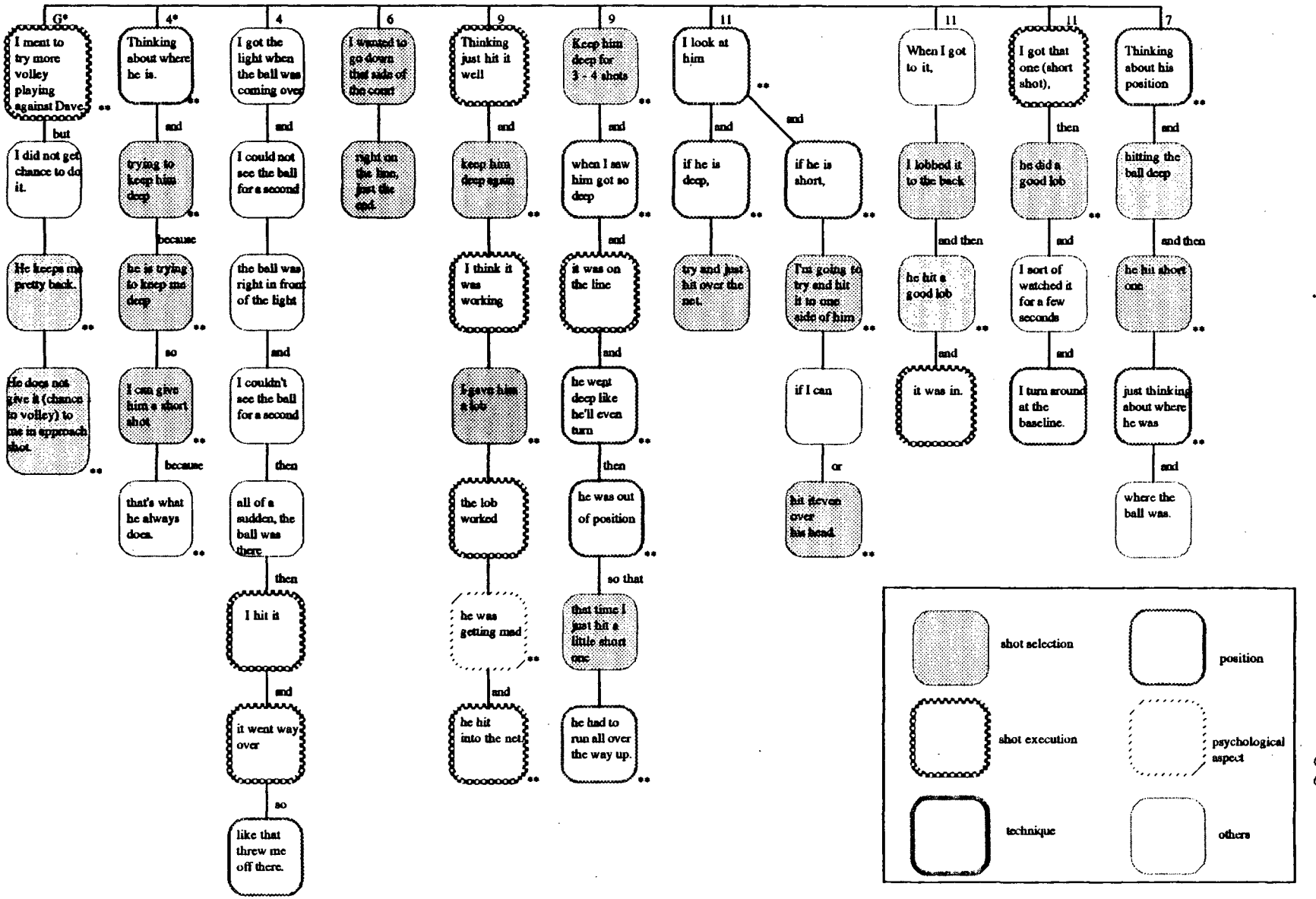
> Situation: After she hit her second serve with moderate speed, the opponent hit a very short return shot which was like a drop shot to her backhand side and it was forcing Colleen.
>
> I. When he hits a short shot, and when you are running to the net, were you thinking about something?
> C. I looked at him and if he is---, if he is deep, I try and just hit it over. If he is short, I'm going to try and hit it to one side of him if I can. Or even over his head if I can hit it.
> I. So when you are running to the net, you see his position.
> C. Yeah. (3/S/F/11)

As it happened in the above situation, C.A. hit to the center of the deep zone with her backhand and took position at the net. Her opponent hit a deep forehand lob and C.A. immediately went back to the baseline

Figure 6. Thought Cue-Linking: (rally situation) Player -- C.A. -- day 3

* G = general comment before seeing the video
Number = the particular point played

** Comment on the opponent



intending to hit this lob with a ground stroke, but she could not execute it. Although it seemed that she made good decision and intended to hit deep and come to the net, she could not fully exploit the advantages of the position she had succeeded in maneuvering herself into.

Similarly, on the same day, when she was the receiver, she also reported alternative shot selection on one occasion, as shown below:

I. How about when you hit a quite good shot to the side of the court, when you hit that shot, were you thinking about the next shot, where you want hit it?

C. Probably the opposite side because I drive him to that side. I would either be on the opposite or the same side depending on if he is going to run to the next side...Like if I hit it to the right side, and he runs over to the right side to hit it, and then I'm going to hit it, and I see him running all the way to the left side. I might as well go right back to the same side again.

I. Yeah, that is one of the tactics.

C. Yeah. So, I don't think I've made the decision of where I'm going to hit it next. But I usually think of two things that I can do or something maybe...(I. Yeah, so...). Like when I hit it to the right side there are two things I can do. I can hit it to the right side again, or I can hit it to the left side, easily one of those two. So, if... (3/R/S/10)

From these instances, in relation to her shot selection which has more variety than the other three players, it appears reasonable to say that her thought is more functionally oriented in the game situation than the other players. During the structured recall session when the players were asked, "Were you aware of your position" and, "Were you aware of his [the opponent's] position?", C.A.'s answers were always simply " Yeah". In fact on the first day she answered, "Yeah, I knew where he was all the time." (1/S/S/8)

Another interesting thought reported by C.A. was that, on the second day, she felt that the opponent's "harder shots" were easier to return than

his "softer" shot. Generally, harder shots are thought to be more difficult to handle by novice players. When players become more advanced in their tennis skills, it is a commonly recognized fact that harder shots without acute angles and depths are actually not difficult to return. C.A.'s feeling in this regard would seem to place her in a higher category of players than the other three players.

C. I also notice, too, the harder he hits it to me, the harder I can hit it back. And if he hits it softer, sort of like with no spin and just sort of flat, I have to really try and get something on it, even then, sometimes I can't always get it on the baseline; but if he hits nice and hard to me, and I hit it, it'll go all the way back to the baseline. That was one thing I noticed. (2/R/F/7)

C I like him when he hits it harder. (chuckle). Makes it easier. (2/R/F/7)

Although she reported some higher level performance characteristics (e.g., focusing more on the situational cues and some strategic cues), as it was mentioned previously, she did not seem to be able to take the fullest advantage of the net position where she still felt uncomfortable. She also reported the belatedness of her judgment of the opponent's lob when she was at the net. She had to think about the technique of the overhead smash because she had not had enough practice of this stroke compared with her groundstrokes (Day 3). Although she had been taught, during the instructional sessions of the course, that she could gain an advantage in taking the net position because that was a more offensive position, it seems nevertheless she had not yet developed a useful set of situational cues associated with taking the net position in her knowledge structure. Consequently, she could not yet take full advantage of these situations.

When the opponent hit a lob when she is at the net, most of the time she would run back to the baseline to try to return the lob after it bounced. The point was either continued with her at the baseline or sometimes ended quickly when she could not get to the lob in time.

She could anticipate or identify the quality (e.g., depth, spin) of the on-coming ball as the ball came over the net. However, on the third day, she reported that she would like to pay more attention to how her opponent moved when he hit the ball. By so doing, she reported she could react more quickly to his shots--as of now she could not react until after he'd hit it. The critical time when she made decision on a shot during a rally was, according to her reports, generally when the ball was crossing the net, depending variously on the on-coming shot by her opponent , the position where she was, and where he was.

In summary, her thoughts in the rally situation were more situational (external)-cue oriented. Her thoughts on the situational cues relating to herself and the opponent were often linked within her attention. She was more comfortable at the baseline position than at the net. At the baseline, she could plan tactics in relation to her and the opponent's position and her previous shot. Her shot selection had more variety than the other players.

General Summary

Although the qualities of shot selection (e.g. depth, direction) and the shot execution are still not highly refined due to her limited experience of practice and tennis games skill, she reported a large number of situational cues and variety of shot selections when she played at the baseline. Her many years of open skill performance experience, such as in soccer, may also have facilitated her ability to extract important external cues and to

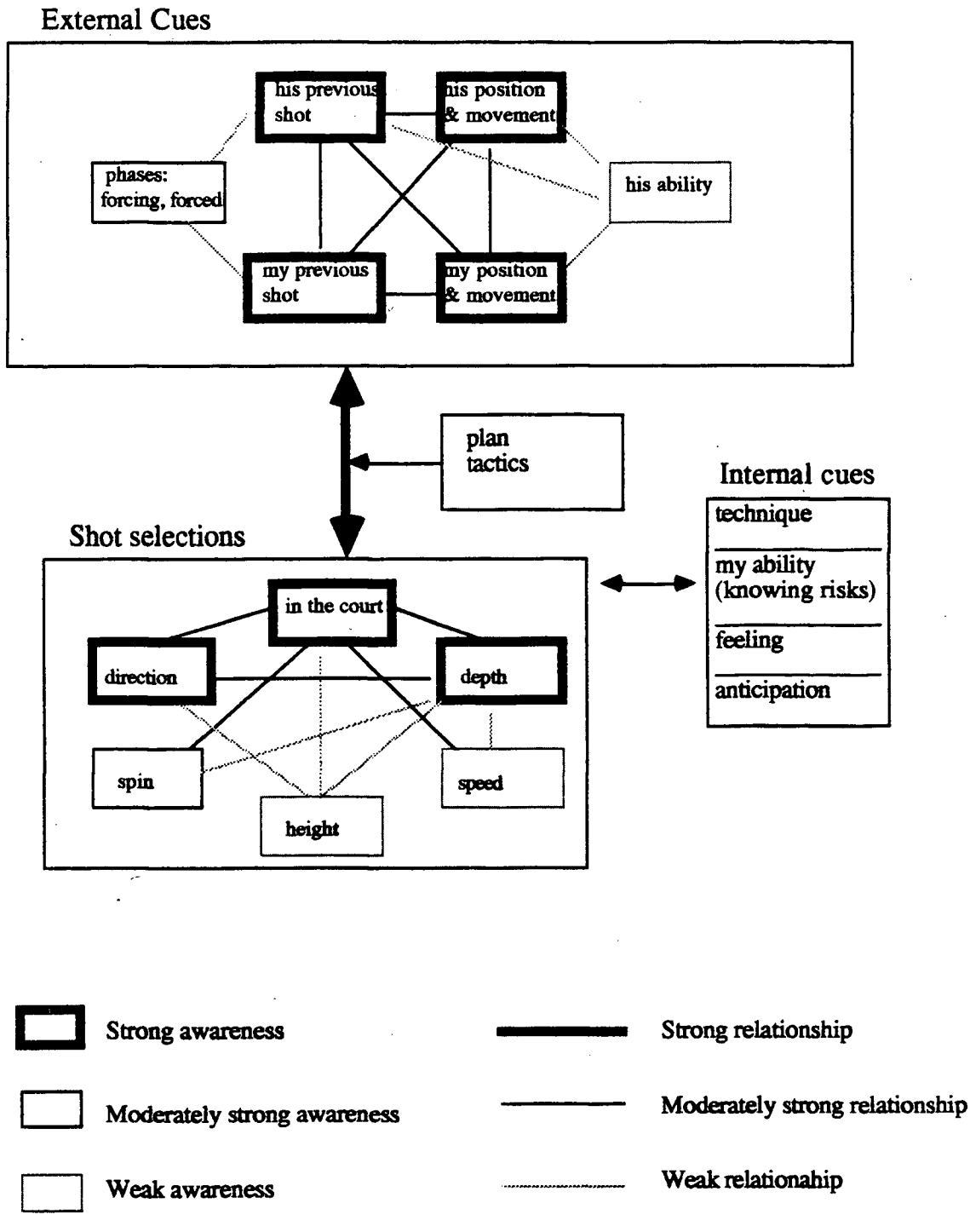
organize those cues in a more structured and effective manner. However, when she applied newer tactics such as advancing to the net position, she had difficulty to deal with the situational demands. Also, it seems that the transition from service to rallies (i.e., from closed skill to open skill) was smooth in her case. Although her serve was not technically refined, she did not worry so much about it as she attempted to move from the service situation into the rally situation where she would have more chances to force her opponent.

It should also be mentioned that she seldom reported her feelings toward points and games. Her emotional status appeared to be almost all the times either neutral or positive during the game. Only on the fourth day when she was not executing her serve well, did she comment that she was frustrated. Her attention was almost always on task, focusing externally and solving problems in the situational context.

Her perception of her performance progression during the four weeks was reported in the Thought and Performance Development Questionnaire. She felt that, as stated earlier, the video tape replay with interview helped her to speed up her improvement. However, it is difficult to identify her skill progression from either her thought processes as revealed by the interview, or from the performance outcome during the four weeks of this study.

Figure 7 shows, in the form of a diagrammatical summary, C.A.'s verbal reports over the four-week period. Her thought processes and knowledge structures are depicted in a map form: indicating the perceived interrelationships among the many variables. Different connections drawn by bold-faced, solid, and dotted lines show the different gradations of intensity or strength of the relationships among the variables. Different

Figure 7. Diagrammatical Summary Player -- C.A. -- -- Relationship between a Player's Shot Selection Decisions and the Operating External Cues and Internal Cues --



rectangles formed by bold-faced, solid, and broken lines indicate the perceived degree of intensity of the knowledge and thoughts on particular variables. The sizes of the boxes correspond to the volume (i.e., frequency) of the thoughts expressed during the interview on the external (situational), internal and shot selection cues. The strength of the relationships among the variables and the sizes of the boxes are meaningful as general indications of some relative measurement of the thought content of the four subjects' verbal reports. Presented in this fashion, a description of each subject as well as a comparative evaluation of the four subjects can be facilitated for the discussion of the multiple case studies.

As described, C.A.'s thoughts in game situations contained a great variety of cue categories. Moreover, a strong interrelationship existed among these cues. She was aware of where the opponent was, where she was almost all the time and she was also aware of the phases during the game; that is, whether she was being forced or was forcing. In commensuration with the development of her situational cues, her selection of the shots was also characterized by a wide range of qualities. The shots in particular situations (e.g., the time when the opponent had advanced to the net position) also seemed to be selected with a plan or tactical thought and were executed accordingly. She sometimes described alternative ways to return the shot depending on the different situations.

During her playing, her thoughts were generally not concerned with the technical aspects of her performance. Exceptions occurred when she encountered execution difficulties resulting from the use of techniques which were relatively new to her (e.g., overhead smash at the net) or when she had made execution errors on her familiar shots.

It seems that her knowledge about the basic technical cues such as ground strokes and serves had been proceduralized (Anderson,1982) and the corresponding action suggests that she entered the beginning stage of automatic performance. In the game situations, her knowledge of the game context had been in a knowledge compilation stage in which knowledge about complex situations is compiled and composed. Moreover, in some contexts in the game situations, especially when she took her position at the baseline, her proceduralized knowledge speed up the application of a number of alternatives in a particular situation (Anderson, 1982). These characteristics are corroborated by her verbal reports. In her verbal reports, the external cues such as the opponent's position and his selection of shots were often linked with her own shot. She reported that she was always aware of where she was and where the opponent was. Her reporting was not disrupted by her technical problems: the situation and shot selection were smoothly interconnected in her verbal reports. It seemed that the more C.A. composed and proceduralized the contextual concepts, her shot selection become more extended and vice versa. From her tennis game and also other sport experience, it appeared that her working memory (Anderson, 1982; Kyllonen & Christal, 1989) had the capacity to permit the choice of some simple strategies for the planning of her shots. However, because of her limited experience of the tennis game, when she was confronted with new situations and tactics (e.g., net position after an approach shot), she had to interpret the situation which resulted in a the slow reaction and/or inappropriate decision making, therefore, she could not execute successful shots.

The general characteristics of this stage of C.A. corresponds well with those of the "competence" stage described by Dreyfus and Dreyfus

(1986a,b) where the learner no longer merely follows the rules but becomes more situational, and goes through the process where he/she learns "to adopt a hierarchical procedure of decision making" (1986a; p.24). "By first choosing a plan to organize the situation and by then examining only the small set of factors that are most important given the chosen plan, a person can both simplify and improve his performance" (1986b; p. 24). C.A.'s stage also conforms to the "adapting" and "refining" stages in ordinative movement category as defined by Jewett and Mullan(1977). Diagrammatically, C.A.'s thought patterns revealed an example of the development of a player's thought processes and knowledge structures in which there are not only extensive external cues and shot selections, but also stronger relationships among these cues.

With reference to the National Tennis Rating Program, CA.'s performance level was evaluated between 3.0- 3.5 at the conclusion of the tennis class.

4.2. Case Study 2. Player R.M.

R.M. is a 24-year-old BPE student majoring in physical education. He indicated that he had about 15 days of tennis experience before taking this tennis class and he was evaluated at a 1.0 rating on the National Tennis Rating Program scale by the instructor. He also had experience in other racquet sports such as badminton for four months and squash for three days and categorized himself as novice in these sports. He had nine years of competitive wrestling experience and is currently competing at the national level. In addition, he played hockey for 15 years and had some

experience with rugby as well. Someday he would like to be a physical education teacher, a wrestling coach, or work with the juvenile delinquents.

His responses to the Thought and Performance Development Questionnaire administered at the conclusion of this study were very positive, commenting that the video tape replay analysis and interview process were both very effective in helping him improve his skills and making him become more thoughtful about his game while playing. Especially, he reported that having video tape replay and interview at the same time had been most effective in stimulating his thinking about his performance, and he attributed his improved game skills as being the direct result of increased cognitive involvement during play.

The following is a summary of R.M.'s reports on his performance as interpreted from the transcript of his interview.

Serve

He constantly expressed his feelings and emotions associated with the points and games played, especially in accordance with the simple fact that his serve was in or out. His positive or negative emotional expressions in relation to "get it in", or "missed", respectively, would exert noticeable influence on his games during the five minutes of play. For example:

> R. I was just getting madder and madder at myself 'cause I was serving wrong. When I get mad, I just get tight, and I don't serve well anyway. So it's kind of like counter productive. (2/S/F/5)

> R. I was still thinking a lot about---,You see that, that one, made it in, so now I started to make the shot and, make it in. And as I make the more, more shot that I get in the more serve, I

> think, the rest of the game, it's getting better, because I feel more confident with myself. (1/S/F/7)

His main consideration on his serve was just to get the ball in the service court. For this purpose, he would sometimes try to hit a "lob serve" (i.e., very soft and high in the air before landing in the service court) As well, on the third and fourth days, with one or two exceptions when he commented on the placement or direction to aim his serve, he again mainly just tried to hit the ball into the service court, and was quite happy when he was successful.

He often attributed his service mistake to his technical problems such as the angle of the racquet face, the hitting point, and his jerky movements. Especially on the second and the fourth days when he hit more double faults than on the other two days, he focused frequently on analysis of the technical problems of his serve. For example:

> R. But, as to what is going through my mind, I was just trying to figure out what I was doing wrong here. I can feel my body wasn't ready, I could feel my arms, I can feel the ball was not high enough, everything else, and then it is almost like getting more and more frustrated; the more I knew about how to fix it, the more things kept going wrong. I could feel my arm was not fully extended when I contact with the ball, I could feel my thigh was not stretched, the ball was not high enough, and just everything. My arm , I can feel the racquet face wasn't where I wanted to put the ball. And then, as I try to compensate for one thing, something else would change. So the whole thing. But then later on in the film, I started this, I said, "O.K., let's get the ball going," so I make a couple of easy serves, and just get rallying. (2/S/F/7)

On the fourth day, R.M. reported that his service delivery was distracted by the thoughts about the opponent's position in relation to his service

direction. He was trying to find the correct way of serving and was hoping to achieve this by slowing down the speed of his serve. When he switched his thought on his serve back from that with directional concern to that of consistency(i.e., only trying to get the serve into the service court), he reported that he no longer had any problem with his serve. This was different from the second day when he also had service problems which he could not solve. It seemed that on the fourth day, ultimately, he had more control on his serve, and he could also control his emotional status even after the problems had occurred.

In summary, the fact that his serves "got in" consistently or not was very important in determining his emotional status. Most of the time he was just trying to hit the ball into the court, and he even resorted to "lob serve" to make sure the serve landed in the service court. When his serve result was relatively consistent, his thoughts would shift to the rally situation; but if the serve was not consistent, his thoughts remained mainly on his serve, especially on the technical aspects and he would try to avoid the double fault situation in any way that he could.

Return of the Serves

Most of R.M.'s reports on the return of the serve were related to anticipation of the quality of the opponent's serves, that is, to the best position to return a variety of serves, and to the problem of the proper hitting point. On the first day, especially after he started to play as the receiver, his reports during the interview were almost continuously dealing with his reception of the serves. He was trying to determine how to adjust to the opponent's serves. For example, he reported:

R. ---- I found it's a lot harder to anticipate his shots coming over the net. A lot of his serves are really soft, and they also had spin on them, so I did---, (I. Yeah,yeah, a lot of spin) yeah, just by me , trying to put it the direction where I want to hit it, they would go totally opposite direction. (1/R/F/G)

And also:

I. Could you recall when he started to hit the serve, depending on his form or his hitting point, could you identify---,(R. Where it was going to go?) what kind of serve he is going to hit, top spin serve or very flat serve, could you---?
R. He had a pretty good slice on it, so when he threw the ball up, he might have had a very hard paceful serving, it had a lot of slice on it, so the ball was almost making an arc, drop in and drop out again. So it looks like he's put a lot of power into the ball, but the actual fact, he wasn't hitting that hard. He is putting a nice spin on it, and the ball was actually a lob, lob serve, it wasn't straight down, lob serve. It comes in and as soon as it hits, because of its spin, it just goes out.
I. That is called a spin serve.
R. Yeah.
I. From his form, could you notice (R. Yeah) that before the ball crossed the net, could you notice that?
R. I probably did. I did notice the way he was serving, and I should have compensated before it happened, I'm not quick that way.(chuckle). (1/R/S/9)

It seems that since he discovered that the opponent's serves varied from high top-spin serves to occasionally flat hard serves, his thoughts accordingly turned to that of problem-solving associated with service returns: where to position himself to return the different types of serves. He experimented with a couple of places to find the best spot. For example:

R. Yeah, he has got really good serve, and he can make it look like he is going to serve hard, but he serves really soft, so I was compensating, I was standing quite far behind the baseline.
I. Were you anticipating he is going to hit quite hard?

> R Yeah, hard serve. So, after a while I moved up closer and closer, so as I was almost at the service line when he was serving because some of the serves were really soft. (1/R/F/G)

Especially when he was receiving the serve from the advantage court, he tried to stay very close to the middle line. For example:

> R. --- the one thing when he serves to that side, I remember I'm always lining up when he serves to my backhand side, I'm always lining up close to the service line, right at the mid-court, so I can be ready for a backhand shot because most of his shots come in there, and I've been trying to return them with the backhand.... ((2/R/F/8)

Although R.M. might have planned to hit a good backhand return on the advantage court, he often discovered that he had some problems in his movement toward the ball as most of the time he got too close to the ball to make a good return. He commented on his problem with the backhand return quite frequently during the four weeks. It appeared that, partly on account of his difficulty with backhand return and partly the opponent's high spin serve, he was occasionally trying to return any serve on the advantage court with his forehand groundstroke. For example, on the third day, he tried to take his position close to the singles sideline to receive his opponent's serve with his forehand groundstroke which he thought to be his stronger stroke (i.e., stronger than his backhand stroke.) (3/R/S/7,8) He was found using the forehand return again on the fourth day although the serve was hit close to the side line.

As it is mentioned, his verbal reports on the first day were primarily related to his service returns. However, from the second day on,

his reports related mostly to the rally situations following the return of service.

When R.M. was returning the serve, most of the time he was merely trying to return the ball into the court, but occasionally he mentioned his intention of hitting the ball in a particular direction (e.g., 2/R/S/9)

Although R.M. did not completely get over the difficulty of not being able to quickly anticipate the type of serve his opponent was hitting, he seemed to gradually feel a little more comfortable when receiving the serve, and appeared to be developing the ability to identify various cues and characteristics of the serves as the ball was coming to him. The following excerpt from his report on the fourth day shows both his continued difficulty with receiving the serve as well as some mixed feelings regarding his progress:

I. What are you thinking of when you are waiting for the serve?
R. Trying to...,trying to get in the position to where I can get the ball over. Usually I think I have run right up right away. When Dave usually does this, he'll play a couple of short ones together. He usually mixes them up, so it is really hard to understand where he is going to put it. So I just play it as it comes over the net. We can't really play it by the way he serves, by his position, because almost all the time it's almost the same speed and the same mo...(I. motion?) motion, so you have to play as the ball is coming toward you and as it comes over the net.(I. Yeah) Because each one is different.
I. So from his motion, you cannot tell (R. Yeah) what kind of serve is coming to you?
R. Even when the ball comes just, if there's a short one with a lot of spin on it, as soon as he hits, it bounces out right away, so you have to be in the position all sort of..., if the ball lands here, you know it's not going this way or that way, so you get around here.
I. So after he hits the ball, and when the ball is still in the air, can you tell whether the ball gets the underspin after the bounce or not?

R. Oh, yeah. I can tell that. I can actually tell that just before because how much of an arc my side coming through the air.
I. Could you tell before or when you started tennis?
R No, I have no idea. No, everything is new.
I. Now you can see a little more than before?
R. Oh, yeah. A lot more. (4/R/S/14)

On the whole, R.M. did not display much negative emotion (i.e., negative self-talk) during the games in which he was the receiver. It seemed that he felt the execution of a service return was less stressful and he could control his tension and relax a little bit more on his service return as compared with the times when he was the server. On one occasion on the second day, even when he made a mistake (moving too close to the ball) on a service return with his backhand groundstroke, he did not seem to be distressed. He reported the incidence as follows:

R. See that one there, I get in, I ran right into the ball again, I was running too fast and did not think about stopping and connecting, setting up before the ball comes. Here is another one.
I. What were you thinking?
R. Uh huh. Work on my backhand. A lot of work on it. (2/R/S/8)

In summary, his thoughts on his return of the serve were mainly related to three matters: where to position himself; his endeavor to anticipate the serve, and to find the correct hitting position. This is especially true on his backhand return in the advantage court. Though he could gradually cope with the different serves, his thoughts were, however, still mainly focused on returning the serve into the court. He rarely talked about the tactical aspects of his service return. When he was playing as the receiver, most of the time his emotional status was positive, and he felt comfortable with the return of serve situation.

Rallies

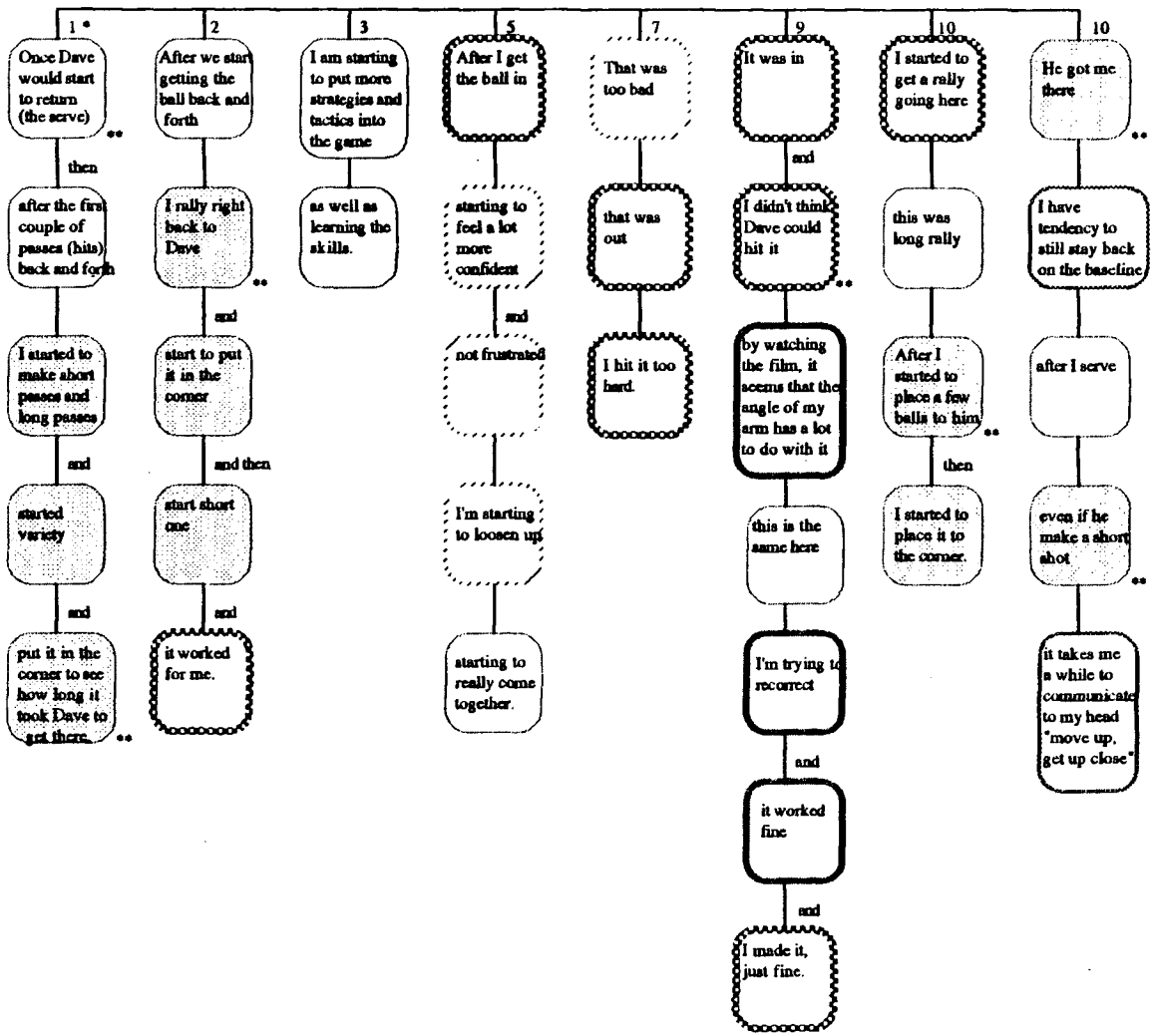
On the days when R.M. played well as the server (i.e., days 1 and 3) and as the receiver (i.e., days 2, 3 and 4) when his thoughts were so much involved in trying to determine the best way to receive the serve, he presented a great variety of thought and attention cues. Figure 8 shows one of the examples of his cue-linking. In the rally situations, he reported with regard to his emotions, his technical corrections, his and the opponent's shot selection, position and the result of the shots as the Frequency of Thought Variable Table (Table 5) shows. He often commented on the outcome of the shots : whether his shot execution was good or not and whether it was successful or not (i.e., evaluation of his shots). When he could maintain the rally for a while, he expressed, from the first day to the fourth day, that he felt comfortable, confident, and enjoyed playing the game.

His thoughts and attentions were often on situational cues such as his and the opponent's positions and shot selections. (It should be mentioned here , however, that he once admitted to not knowing his opponent's position during a structured questioning on the first day.)

His shot selection was, on the first day, relatively simple and he just intended to hit the ball into the court. On the second day while he was playing as the receiver, his responses indicated that he was thinking about some tactics. The situation was as follows:

> (Situation: there had been a fairly long rally (10 exchanges in the point) and at last Rick hit a backhand passing shot when his opponent was at the net. It turned out to be the winner of that point) :

Figure 8. Thought Cue-Linking: (rally situation) Player -- R.M. -- day 3.



* Number = the particular point played

** Comment on the opponent

Table 5.

Frequency of Thought Variables

Name __ R.M. _ Number in O = negative remark

SV= serve, RL= rally, TL= total

	day 1			day 2			day 3			day 4		
	SV	RL	TL	SV	RL	TL	SV	RL	TL	SV	RL	TL
1. Feeling												
Emotional cont'l-Arousal				1		1	1		1			
-Thought	3	8	11	1 (4)		1 (4)	4	1	5	1 (3)	3 (2)	4 (5)
Attention cont'l-Concent'n	2		2	1 (0)		1 (0)				(0)		(0)
Mental practice												
2. Planning for today												
3. Input relevant cues												
the ball movement		1	1					1	1		1	1
his movement & position		2	2		1	1		3	3	2	1	3
his shot selection		1	1					1	1		1	1
his shot execution		1	1					2	2		1	1
my movement & position		3	3					1 (1)	1 (1)		2	2
anticipation		1	1		(1)	(1)		(2)	(2)		(0)	(0)
4. Response selection												
in the court	1	2	3	3		3	4		4	3		3
direction		2 (0)	2 (0)				1	5	6	2 (0)	1	3 (1)
depth								2	2			
height					1	1	3	2	5			
spin												
speed	1		1	(0)		(0)	(2)	1	1 (2)	2		2
offensiveness												
defensiveness (rally going)					2	2		1	1		1	1
strategies (shots ahead)								1	1			
5. My response execution												
good	4	6	10	2	1	3	3	4	7	2	1	3
out/not intended				2	1	3	4		4	4	1	5
6. Analyzing												
my technique	4 (1)	(0)	4 (2)	5	1	6	6		6	8	2	10
my shot selection								1	1			
my level	1		1		1	1	2	1	3	1	1	2
his level												
7. Evaluating												
what I did (good, bad)	4	3	7	3	1	4	3	3	6	3	2	5
I did not know what to do												
I could should) have --								3	3			
He could have --												
8. General comment												
9. Off task thought	1		1	1		1		1	1		2	2
	(1)	(2)	(3)	(6)	(0)	(4)	(2)	(3)	(5)	(5)	(3)	(8)
Total	21	30	51	19	9	28	31	34	65	28	20	48
performance results												
1st serve in	6/11			3/10			6/10			4/11		
2nd serve in	3/5			1/7			2/4			2/7		
Rallies: total/ x=	41 / x=3.73			24 / x=2.4			49 / x=4.9			43 / x=3.31		
won/lost	6/5			1/9			4/5 (1)*			7/9 (1)*		

* uncertain result

R. This point there. I was trying to make, trying to make, see, I'm very inconsistent, but when they do come in it's kind of a nice feeling. But I'm trying to think a lot more about tactics, and so is Dave, when he was playing up close to the net, and obviously I'm trying a lot of back and I made that point on him (I. Good, good.) So I'm starting to think a lot more about where to place the ball.
I. Uh,huh, Very good.
R. Even though my skills of getting the ball there isn't that great, but I'm starting to think more involved in the whole game, rather than just batting the ball over the net now. (2/R/F/7)

The tactics of the second day were rather simple: Rick just tried to aim in particular directions. However, on the third day, his thoughts touched on a great variety of shot selections in respect to the depth and height of the ball, and he even talked about strategies (i.e., thoughts on the next shot to be played) as evidenced in Table 5.

The difficulty with respect to the problem of anticipation, which he experienced as a service receiver, was also experienced here during a rally as Rick could not anticipate the opponent's shot by watching his movement. For example, this is evident in the following remarks on the third day, when Rick was the server:

I. From his back swing, or, before he hit the ball, can you tell what kind of shot he was going to hit, or is it difficult to say?
R. For me, at that point, it was difficult. I can tell he wasn't going to plow it over the net because he already had it into a groundstroke position. So I just didn't react quick enough, basically, I think. Most of my..., some of the things like, I'm still playing on action-reaction. I'm not judging ahead of time what he is going to do, most of the times. I'm using the action-reaction, so I'd see him react, and I react to that action. So I'm not anticipating his movements yet. (3/S/S/10)

To a structured question which asked:"How soon could you anticipate or identify the kind of a shot next coming to you from your opponent during the rally?", his response was:

R. It's not when he hits. It used to be when the ball crossed the net, and in some cases it still is; but most of the time now it's when I see the ball coming towards me. Instead of before it comes across the net.
I. Before it comes across the net....
R. I try to, anyway. (4/S/S/8)

On the fourth day, he was beginning to take the net position occasionally. He found that it was fun to play there, even though sometimes he was lobbed over or was passed by the opponent.

In summary, when R.M. could keep a rally going after the serve or service return, his feeling was very positive. It seemed that, even though the performance outcome does not show this, he developed his schema on the rally situation a great deal. His thoughts and attentions on the situational cues and his variety of shot selections increased from the first day to the third day On the fourth, he did not talk too much about the rally situation because of his ineffective serves which occupied much of his attention. He reported that he could anticipate the ball a little sooner on the fourth day. In relation to his development of a focus on the external cues, he also reported that he started to think about tactics and such matters as to where to hit and how to hit the ball.

General Summary

His verbal reports clealy indicated the development and progression of his thoughts on the rally situation during the four weeks. Actually he

was the only player who demonstrated, through the verbal reports, this extensive progression from the first day to the fourth day. The extension of his thoughts and attention from technical matters to situational cues and his shot selections seem to have been gradually organized and structured during these weeks. Although on the fourth day, he did not reveal his thoughts on the rally situation frequently because his thoughts were caught by the opponent's position before delivering of his serve and it distracted the concentration on his serve, however, he had more control on his serve if he switched his thoughts to just focus on "getting it in" and extended his thought to the rally situation. Also, he developed the new position (i.e., net position) for his strategy on the fourth day. From these evidences, it should be appropriate to consider that his thought had developed and progressed in respect to the rally situation during the four week.

His reports indicated that, at first, he could not perform a variety of shots and just tried to hit the ball into the court or in some specified direction, although these reports did indicate his awareness of the external situation. However, gradually, his consideration of a growing number of various situational cues interacted or linked with his intention to select a variety of shot alternatives and his tactical thought expanded.

This improvement of his thought expansion during the rally in the four weeks was evident in his performance on the video tape. At first he took his position in the so-called "no-man's land" quite frequently after the serves and returning of the serves. He was instructed not to stay in this area and gradually his positioning on the court improved, and he started to take a position either at the baseline or at the net position as the situation demanded.

He had to focus attention on his serve and the return of the serve. On his service, especially, he had to concentrate and he consistently focused on and analyzed the technical points. Gradually he could control his serve and, accordingly, the transition from service delivery to the rally situation became smoother than the initial stage.

During the interviews, he often expressed his emotion during the game and it was as if he was re-experiencing it. He related negative thoughts and self-talk (e.g. frustration, being mad at himself) associated with his many double faults. Other than that, he appeared to have enjoyed and felt to be quite comfortable playing the game.

When responding to the Thought and Performance Development Questionnaire, administered at the conclusion of this study, he reported on the perceived improvement of his game and attributed it to the development of his thoughts toward his tennis game by the interview and video tape replay analysis procedure. Similarly, during the interview sessions, he also expressed his belief in having benefited from video tape replay analysis. However, just as in the case of the other players, the Performance Outcome Summary (Table 3), itself, does not indicate clearly the improvement and progression of his performance as claimed.

Figures 9a,b present, in the form of diagrammatical summaries, R.M.'s thought processes and knowledge structures as constructed from his verbal reports of the initial (Figure 9a) and the final stage (Figure 9b) respectively. The comparison of these two figures represent the processes of his adaptation in the tennis game situation as we can see the development in his thoughts. One is the extension of his thoughts on the external cues; the other is the development of his variety of shots. The development of,

Figure 9a. Diagrammatical SummaryPlayer -- R.M.: initial stage --
-- Relationship between a Player's Shot Selection Decisions and the Operating External Cues and Internal Cues --

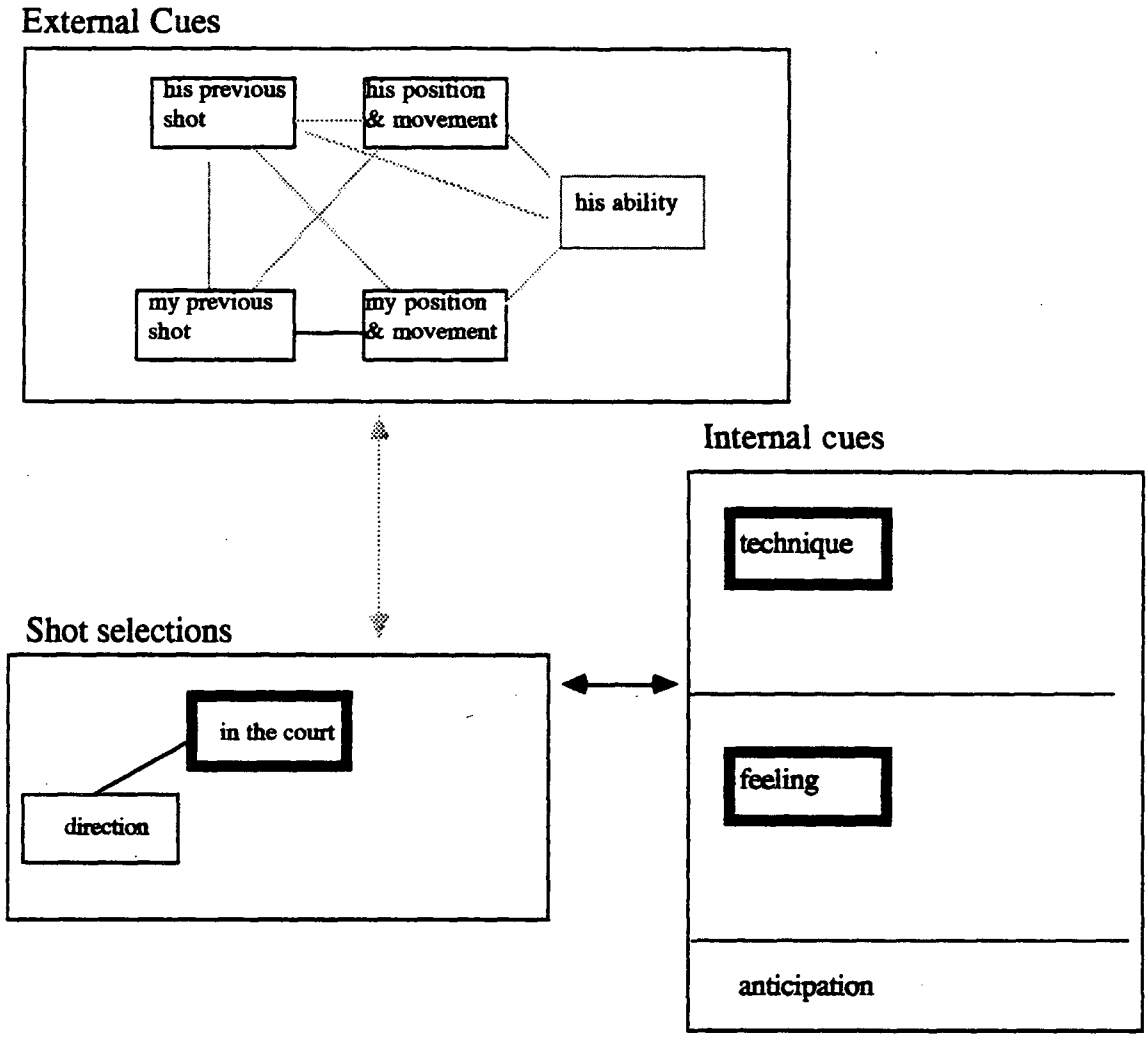
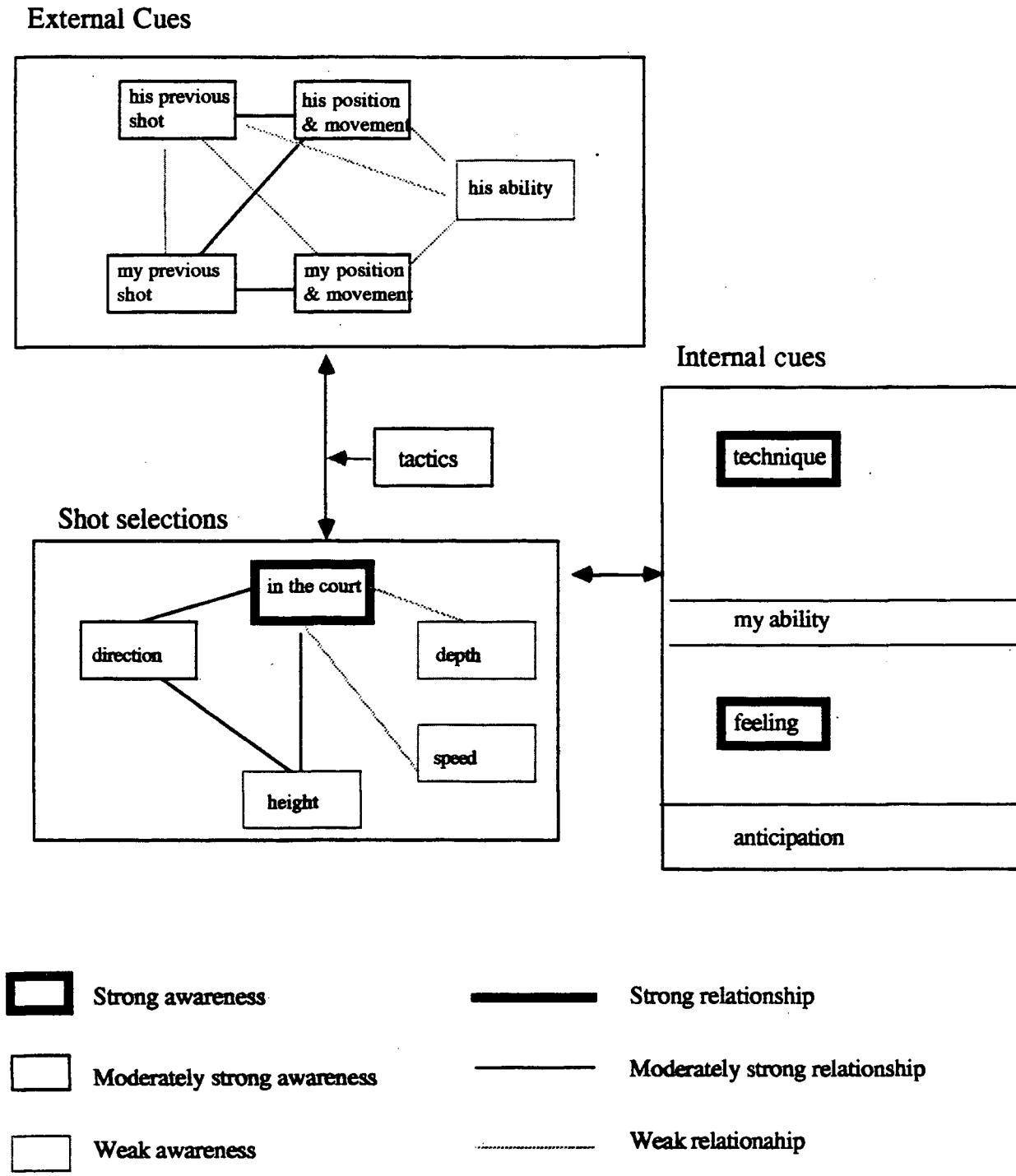


Figure 9b. Diagrammatical Summary Player -- R.M.: final stage --
-- Relationship between a Player's Shot Selection Decisions and the Operating External Cues and Internal Cues --



and the interaction between the two further stimulate each other, and accelerate the player's progress.

At the initial stage, as shown in Figure 9a, his thoughts associated with the relationships among the external cues were weak (i.e., little evidence, if any, of a functional relationship) although he was aware of the important cues in the situation such as the opponent's position and previous shot, and his developing schema started to include some of these cues. In other words, these cues existed as separate entities, and the interrelationship among them was weak, which resulted in the delay of his responses. He often commented that he needed to anticipate better in order to react more quickly.

This stage of his game experience could be described as the "declarative stage" by Anderson (1982). This declarative stage, according to Anderson, involves the new information being entered, then "interpreted" and stored in the working memory. Because of this interpretation process, the performance is slow and errors are unavoidable. Moreover, as Anderson describes, if the information content is too extensive for the person's working memory capacity (i.e., too many conditions are presented compared with the capacity to interpret the information in the situation in order to make some decision on a particular action), then the activation of the condition is delayed or on occasion never applied. In R.M.'s case, at this stage, it seems that his working memory could not quickly activate on or select from the variety of situational cues because of his limited game experience as he was not yet capable of the clear and immediate identification of the functional relationship among the external cues.

On the other hand, in order to avoid the unforced errors and to get into a longer rally, his thoughts were often dominated by his technical analysis. His tendency to focus on technique (i.e., how to hit shots in appropriate way) was, at this stage, only weakly related to the situational cues which indicated that he was still in the "context free" stage as described by Dreyfus and Dreyfus (1986). His primary consideration during each shot execution was to hit into the court with appropriate techniques. Therefore, his thoughts about "the game" seemed to be in a passive (i.e., defensive) mode, and he was pleased just to "get the ball back" whenever he could and avoid an unforced error.

In the final stage of the four weeks, as shown in Figure 9b, his comments indicated that his approach to "the game" moved to a slightly more active (i.e., offensive) mode. His play began to reflect a greater variety of intentions with respect to his shot selection in relation to his opponent and himself. Moreover, he began to think about tactics appropriate to his level. He appeared to be gradually leaving the declarative stage with respect to the situational consideration and was starting to "compile" (Anderson, 1982) the important cues in the situation in relation to his shot selection. However, his technique was still imperfect, consequently, his thoughts always reverted to his technical problems and problems of late anticipation whenever an error was made.

R.M.'s progression also seemed to conform to the "advanced beginner"stage, described by Dreyfus and Dreyfus (1986), where "recognition of situational elements based on experience rather than rules" (p. 50) becomes an important factor. The advanced beginner now explores both the situational and context free components in a real situation. In terms of the "movement process categories", proposed by Jewett and

Mullan (1977), R.M.'s performance was primarily that of a "patterning" of the various shots in situations. He gradually moved to the stage where he was at an "adapting" level where his shots were successfully completed within different conditions.

With reference to the National Tennis Rating Program, R.M.'s performance was evaluated by the instructor as being between 2.5 to 3.0 level at the end of this study.

4.3 Case Study 3. Player S.T.

S.T. is a 22-year-old BPE student who estimated his tennis experience, prior to enrolling in this course, to be 10 times over a period of one and a half months. His performance level on the National Tennis Rating Program scale evaluated by the instructor at the beginning of the course was 1.0. He had about two years of experience as a recreational player with racquet sports, such as, badminton and squash. His other athletic involvement included 16 years' of competitive downhill skiing, 16 years of Ukrainian dancing and 10 years of cycling experience. He aspires to be a university level physical education teacher in the future.

S.T.'s responses to the Thought and Performance Development Questionnaire administered at the end of this study affirmed the effectiveness of the videotape replay and interview as means of stimulating the development of his thought on his tennis games. The joint use of the video cassette replay and interview was, in his opinion, most useful with the interview being especially effective in the identification and correction of his mistakes. He stated that this source of feedback was invaluable to

him as he was, otherwise, not sufficiently experienced to discover his mistakes and institute corrections accordingly. He repeatedly commented on the effectiveness of the interview in the Questionnaire.

The following is a summary of S.T.' verbal reports on his performance, as described and interpreted from the transcripts of his interview session.

Serve

Most of the time he was concentrating on just getting the serves into the court. He reported that, on the second day, he made a few attempts to hit the serves in particular directions in order to move his opponent around, but when he found he was not successful, he reverted back to just hitting the serve into the service court. In order to get the serve in the court, his thoughts were mainly on the necessary technical corrections. His efforts at achieving technical correctness were explained in quite precise detailed analysis. For example, the following are comments Steve made on his serves on the second day:

> S. Here, there are a couple of services in the raw where I put it right off, I was hooking off to my left and so I had been doing that earlier too when I was playing with Wayne. So, there, after I hooked it to the left the first time, I was concentrating more on changing my foot position a little bit, so I'd be turning my body a little bit more towards the center of the court. And, also, in pronating my forearm, when I was actually hitting the ball instead of, I think before, I wasn't quite pronating well enough. (2/S/F/10)

He was particularly concerned about the correctness of the toss, and about coordinating it with the hitting point to achieve some measure of

fluidity in the service action (the first example below) and also about coordinating the toss with the backswing (as shown in the second example below):

(1). S. Right now, I'm a little bit concerned about my serves. Just, they don't, the motion just doesn't seem to be as fluid as it was, you know, last Thursday, when I last played. Seems it's, it feels a little uncoordinated today. So, mostly, I'm just concentrating on throwing the ball up, and trying to contact it at the right spot. (4/S/F/5)

(2). I. Can you recall what you were thinking ?

S. It's just basically get it in. I'm sort of experimenting all the time with my throws, I don't think my throws are that consistent. Some are right, sort of straight over top of me. Other ones are a little farther out. I find that my best success is when I just throw it just in front of me. So, I'm actually reaching forward to get to it, you know, and but I don't have the consistency yet in throwing it up. I'm sort of...

S. At the same time, I'm trying to concentrate on relaxing my arm for the backswing. You know, I don't think I'm attending to both, both motions. I'm attending to my relaxed backswing as opposed to not worrying, really worrying about my throw because I thought that it was more consistent than this, but today it seems to be awkward. (4/S/F/13)

Especially on the first day and the fourth day, his thoughts were frequently found to dwell on his technical problems than they were on the second and the third days as Table 6 (Frequency of Thought Variable Table) indicated. This difference, incidentally, was not evident from the relevant data given by the Performance Outcome Summary Table (Table 3). Moreover, on the occasions when his thoughts were on the service, he was also evaluating whether what he did was successful or not.

He reported on the second day, at the beginning of the interview that "My serve today seemed a lot better." Actually, as it was mentioned before, on that day his thoughts on the serve went beyond the point of just

Table 6.
Frequency of Thought Variables

Name __ S.T. __

SV= serve, RL= rally, TL= total
Number in O = negative remark

	day 1			day 2			day 3			day 4		
	SV	RL	TL	SV	RL	TL	SV	RL	TL	SV	RL	TL
1. Feeling												
Emotional cont'l-Arousal												
-Thought				2	1	3	1	2	3		1	1
Attention cont'l-Concent'n	5		5	3	2 (1)	5 (1)				1		1
Mental practice												
2. Planning for today												
3. Input relevant cues												
the ball movement		1	1		1	1		1	1			
his movement & position				3	(1)	3 (1)					3 (1)	3 (1)
his shot selection		3	3		3	3		1	1		2	2
his shot execution		2	2		2 (1)	2 (1)					2	2
my movement & position		3	3		4	4		1	1		5	5
anticipation		1 (1)	1 (1)		(3)	(3)		(1)	(1)		(1)	(1)
4. Response selection												
in the court	3	1	4	1	1	2	1	1	2	3		3
direction	(2)		(2)	6	2 (1)	8 (1)				1 (1)	3 (1)	4 (2)
depth					1	1		1	1			
height												
spin												
speed	(1)		(1)		1 (1)	1 (1)	2		2			
offensiveness												
defensiveness (rally going)		1	1									
strategies (shots ahead)											1	1
5. My response execution												
good	3	1	4	3	1	4	1	1	2	2		2
out/not intended	6	2	8	3	4	7	1	3	4	3	4	7
6. Analyzing												
my technique	11	3	14	3	6	9	2	8	10	9	1	10
my shot selection		1	1									
my level				2	2	4	1		1	1		1
his level		2	2		2	2						
7. Evaluating												
what I did (good, bad)	4	1	5		3	3	1	4	5	6	3	9
I did not know what to do								2	2	1	1	2
I could should) have --										1	1	2
He could have --												
8. General comment				1	1	2		1	1	1	2	3
9. Off task thought	1		1		1	1		1	1			
	(2)	(1)	(3)		(8)	(8)		(1)	(2)	(1)	(3)	(4)
Total	33	22	55	27	38	65	10	27	37	29	29	58
performance results												
1st serve in	6/14			6/12			9/14			7/13		
2nd serve in	2/9			2/6			4/5			2/6		
Rallies: total/ x=	34/ x=2.43			31/ x=2.58			40/ x=2.86			43/ x=3.31		
won/lost	3/11			2/10			1/13			2/11		

putting the ball in the service court: he was also thinking about placement of his serve in particular directions. However, the Performance Outcome Summary (Table 3) does not clearly show that his serves were better on that day as he claimed. The number of first and second serves in and double faults on the second day was quite similar to that of the first and the fourth day. On the other hand, on the third day, performance record on the video tape showed that he could hit quite good serves and he had only one double fault during the five minutes of play. Specifically, he hit good first service in from the fifth point on to the ninth point, and these were technically good services as well. However, he did not comment on these good serves; and his focus was instead on the rally situation following the serve. Moreover, on the same day (the third day), when he could hit technically good services on the tenth and 11th points, he simply commented:

> S. Now it's O.K. I faulted that one. I'll just ease up a little bit on this one and get it in. So the first one I tried to put a little bit more power into it, but not much more. I haven't got to the point that I can put a lot of power into it yet, so. (3/S/S/10,11)

As can be seen, S.T. was not excited about his good serve. In fact, he even commented: "Generally, I was a little bit off today." at the beginning of the interview on this (the third) day.

In summary, his thoughts on his serve were mainly on identification and correction of technical mistakes and also whether the serves were in or out. He was, most of the time, trying to hit into the service court with good technique. His subjective feeling of having had a good day on serve was not corroborated by the Performance Outcome Summary. When the

player R.M., on the other hand, expressed his feeling toward the games, his feelings were most of the time in agreement with his playing results.

Return of Serve

S. T.'s reports on his return of serve were mainly on his errors and his attempts to correct them. He attributed his mistakes to the late identification of the quality of the serves and to his technical faults.

Except for the third day when he talked little about his poor anticipation regarding the quality of the serves, he primarily reported the problems he had with anticipation. Especially on the first two days, before a serve was hit, he prepared to receive a particular shot and only just before he actually received the serve did he realize that his anticipation had been incorrect. The following example illustrates the situation:

S. O.K. That instance, the first shot he made was like a regular serve, there was no lob to it or anything like that. It was long, so I didn't worry about it.
I. Yeah, right.
S. But, as for the next serve, I was thinking, "O.K. Dave's stopped fooling around with the lob serve, and he is going to give me a regular, you know, a middle speed-serve". That's what I was prepared for. I backed up from the line in preparation for it. I'm watching, like, when he actually went through the motion, I was watching the ball in the direction it was coming, and I actually, he lobbed it up again, and actually I thought it was coming to my forehand. And then I realized, oh, oh, it's going to come too short, so I started moving up, and then when I was moving up, I realized that because of the lob, I totally misjudged it. It was coming to my backhand, so my reaction was to quickly twist my upper body to put my back...so I can do my backhand stroke. And I mishit it just because I did not have enough time. (1/R/F/8)

On the second day he reported he could anticipate better than before, but he occasionally reported similar misjudgment in anticipation as the previous quote describes. On the fourth day he also reported problems relating to his anticipation. But on this day, S.T. did not provide as much elaborate and specific details regarding his pre-set and misguided preparation. He reported much more simply, for example:

S. I was late anticipating for the serve. (4/R/F/8)

S. I just had a real tough time anticipating exactly when the ball would be, so it's just that I mishit it because I didn't get to the ball properly. (4/R/S/11)

On the third and the fourth days, when he was asked the questions related to anticipation, he reported successful identification of the types of the serves such as the hard (i.e., flat) serve and spin serve, as well as the quality of the on-coming ball. The following quote illustrates this:

S. Yeah, well, watching the whole stroke that he makes, and especially when he starts to actually swing at the ball, you can almost pick it out there, in terms of what kind of serve it's going to be. So whether it's going to be a hard serve or a soft serve. So, it's a lot easier for me to anticipate whether it's going to be one of his looping, lob-like serves, or whether it's going to be a hard serve, just by watching---, the swing to the ball , and then it's only...

I. You mean, "to the ball" means backswing?

S. Yeah, the backswing. Uh, huh. And then, you can sort of pick out the general direction whether it'd be forehand or backhand within the first half of the flight of the ball before it crosses the net. And then only after it crosses the net, probably you can or I can determine exactly where it's going to be coming. And more or less after the bounces. O.K., that's exactly what it's going to be, so... (4/R/S/G)

He also reported that the causes of the mistakes on the return of the serves were problems of technical deficiency. He often analyzed his upper body movement in relation to a coming ball, the over use of wrist at the hitting point, and hitting downward as trouble points.

Most of the time he was just merely trying to return the serve into the court, with appropriate technique. From the second day to the fourth day, however, on occasion he also reported his intention to hit his return of the serves to the opponent's court in specific directions. The following quote will illustrate:

S. There I was intending, actually, to put it really short and really sort of like in the corner, left hand corner of the service zone, but I just hit it like a foot too far, basically.
I. I see.
S. So,but that was, my intention was, to put it there because I knew he wasn't going to move for something like that.
I. So it's a good process, I can see the process of what you are trying to do.
S. Yeah.
I. Before, you were not aware of that kind of thing.
S. Before, I was mostly concentrating on just trying to make a good stroke. It's starting to click now, but you can sort of see, comparing this tape to the previous tape, what we did today and my stroke are sort of regressed a little bit. And I started having more trouble with my strokes again, but at the same time, I'm trying to concentrate more on where I am going to put the shot. You know, actually thinking a little on the strategy. (2/R/S/8)

In summary, his reports on his return of the serve were mainly related to his technical errors. He attributed his errors to his faulty anticipation and technical deficiency. However, he reported improvement in his ability to anticipate in the course of this study, and as time went on, he reported his being able to identify the types of coming serve (i.e. flat

and spin) by the opponent's racquet movement. In the beginning he was only trying to hit good return of serves in the court. But from the second day onward, he reported his intention of returning the serve in specific directions in relation to his opponent's position.

Rallies

As the Performance Outcome Summary (Table 3) shows, his rallies were not prolonged, in fact, they were often terminated on the third stroke after S.T.' serves (i.e. after his first stroke following his serve) or on his service return. He reported that one of the problems that caused the errors on his rallies was that he could not manage a smooth transition from his serve to a rally, or that he could not go smoothly from one point (in a rally) to the next. The reasons may be, as he seemed to try to explain, due to the fact that he often was paying more attention to, even admiring, his own shot, rather than watching carefully how his opponent was reacting to his shot. The following report of his shows this situation well:

S. Yeah, again, there, Dave did a nice sort of soft shot. It wasn't a lob or anything like that, it was just a soft forehand stroke, and it caught me off drive. It was my anticipation again of the shot. I stood there watching my shot as opposed to reacting to what he was doing....I still sort of focus on where I'm putting the shot and sort of going, in my own mind, going: "Well that was actually pretty good" or "That was successful" or "I didn't quite put it where I wanted to." While I'm attending to that thought, I'm not really concentrating on what he is doing with the ball.

I. Actually, you hit a good shot and then maybe you were watching .....

S. I think in general it's anytime I hit a shot, it's mostly...I'm mostly concentrating on watching what happened to my shot as opposed to watching how he is setting up for my shot, and how he is going to return it.

I. I see. Yeah, that's a good point.
S. So it's my anticipation of what he is doing that I have to work on a little bit, too, so... (2/S/F/12)

This problem of anticipation seemed to be related to his poor identification of quality or characteristics of the shot hit by the opponent. He often had difficulty with the return of the opponent's underspin shots, and he reported that he mis-gauged them. When he was asked the question, "When do you recognize what kind of a shot is coming to you next?", his response was similar to the one given in the returning of service situation. For example:

> S Generally, you can pick up on the direction almost immediately after he hits it. So the first, just before it crosses the net, you're already lining up in terms of where it is going to come to the court. In terms of speed or whether or a spin or anything like that, it's simply after it crosses the net. So I may get to the right position in terms of the direction that the ball is coming in, but I'm still not able to anticipate where the ball is exactly going to come to or land in the court, because, I'm still not able to measure or gauge in my own mind what the ball is doing. (3/S/S/11)

His reports on the poor anticipation and late identification of the shots from the opponent were particularly numerous on the first, third, and fourth days.

On many occasions, Steve reported situational cues. They were sometimes related to his opponent, such as the opponent's shot selection and shot execution. At other times, they were related to himself, such as his own movement and position. However, he reported very little on the opponent's movement and position, as the Frequency of Thought Variable table (Table 6) shows. These (i.e., thoughts on the opponent's movement and position) were reported mostly on the fourth day rather than on any of the other days, but the occurrence of such thoughts was not frequent.

It seems that his shot selection did not reflect a linkage with any of the reasons why he wanted to hit a particular shot. Most of the time he just wanted to hit into the court with appropriate technique or with some intention of specified direction, but these thoughts were mainly related to the on-coming ball itself, not in relation to the opponent. It seemed that most of the time his thoughts were confined to the ball he was about to hit: in time, his thoughts were concentrated on the moment when he was about to hit the ball, but were not looking ahead to the next moment or anticipating what lies ahead; in space, his thoughts were confined to the immediate environs of the ball he was just about to hit, on his side of the court, and not so much extended to the other side of the net , nor to his opponent there. The following example shows this:

> S. Uh,huh. Like I said before, when I'm attending to what my shot just...what I did with my shot as opposed to what he is doing, uh, huh, I'm not really thinking about setting about for the next shot, you know. When I start thinking ahead of what he is going with the shot, how he's setting up for it, how he is returning it,.... And also, probably I can start attending to actually what I could do for the next shot. Right now, it is sort of, see what's happening and respond to that immediately. See what is gong to happen next, and respond to it. Yeah. So, I'm not thinking ahead yet.
> (2/S/S/6)

S.T. expressed a similar sentiment when he commented that while he was getting to the point where he could better anticipate the opponent's serve, he still had problems with anticipation of the ball in a rally, as the following excerpt shows:

> S. I can now gauge or anticipate where the ball is going to come, how hard it is going to hit, by his line up and his first, you know, the motion of him actually hitting the ball. But that's only the serve, that I can anticipate that. In a rally I'm not

> watching what he is doing with the ball. I'm just watching where the ball is coming or where the ball is moving to. You know, so I'm not watching him yet. I'm focusing on the ball. (3/S./S/11)

His thoughts on the technical corrections in the rally situation were as frequent as they were in the service and the service return situations. He attributed the causes of his performance errors to his technical mistakes as well as to poor anticipation, as described before. Sometimes his comments on his technical points would come in to interrupt the linking of the cues in the course of his relating his rallying experiences in the interview, as Figure 10 shows. It seems that during a rally, his attention was not only focused on the situational cues, but also on internal cues (e.g., how to hit the ball). In addition, he also often commented on whether his shot was in or out, and successful or not.

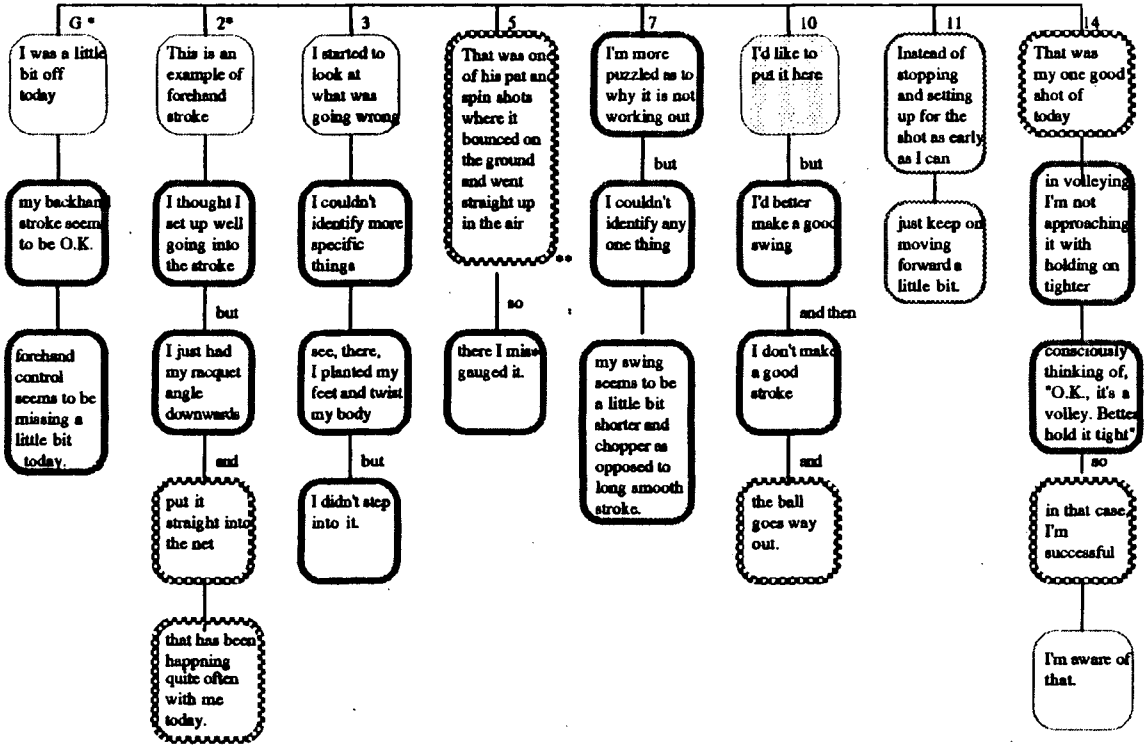
In summary, it seems that his thoughts and attentions in the rally situation were most of the time about himself (i.e. his technique, his position and movement, his intentions regarding the shots and the evaluation of his shots.) Frequently, his analysis about himself was detailed. In other words, his thoughts and attention on the situation were more extensive on his side of the court and less extensive on the other side of the court (including the opponent himself). When he talked about his opponent's shot selections, it was not related to his opponent's movement or position; rather he related the shot from the opponent to himself. He would comment on what he could do with that shot. Moreover, his shot selection decisions (i.e., where he wanted to hit) were seldom related to the opponent.

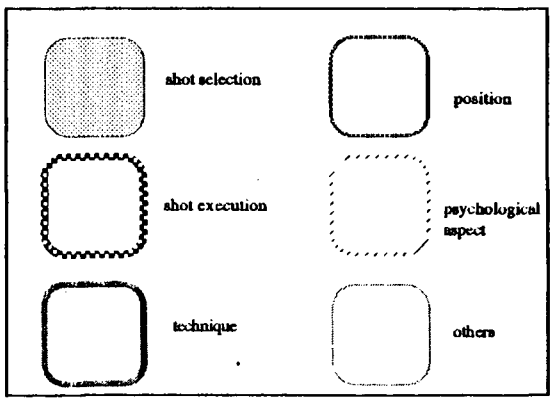
When his thoughts during the interview and the responses to the Thought and Performance Development Questionnaire were compared, it

Figure 10. Thought Cue-Linking: (rally situation) Player -- S.T. -- day 3.

* G = general comment before seeing the video
Numbers = the particular point played

** comment of the opponent





was clear that his focus was primarily on his technical corrections. In the Questionnaire, he commented positively on the interview with the aid of videotape replay, saying that it was helpful in identifying the mistakes and effecting corrections of techniques. His focus throughout was so much on his errors that he seldom commented on the good shots which he did occasionally manage to hit.

General Summary

As repeatedly mentioned in S.T.'s reports on all three components of play (i.e., serve, return of serve and rallies), he was primarily concerned with how to hit the ball with appropriate technique and anticipation and identification of the quality of the shots from his opponent. As he stated in the Thought and Performance Development Questionnaire, his focus was mainly on that of error detection and correction; therefore his reports on his good strokes were rather simply worded, and less frequent than his comments on his errors. Also, he seemed to have difficulty deciding where to move and take position in relation to the on-coming ball because of his faulty anticipation or erroneous identification of the quality of the shots. Consequently he was continually late in getting ready to hit the ball.

On the whole, his focus was mainly related to himself, and he made very limited comments regarding the relationship between the opponent and himself, particularly in rally situations. When he reported on his shot selection, the majority of his thoughts were not smoothly linked with the opponent's movement or situation. It was as if the cues associated with the opponent and his cues existed independently.

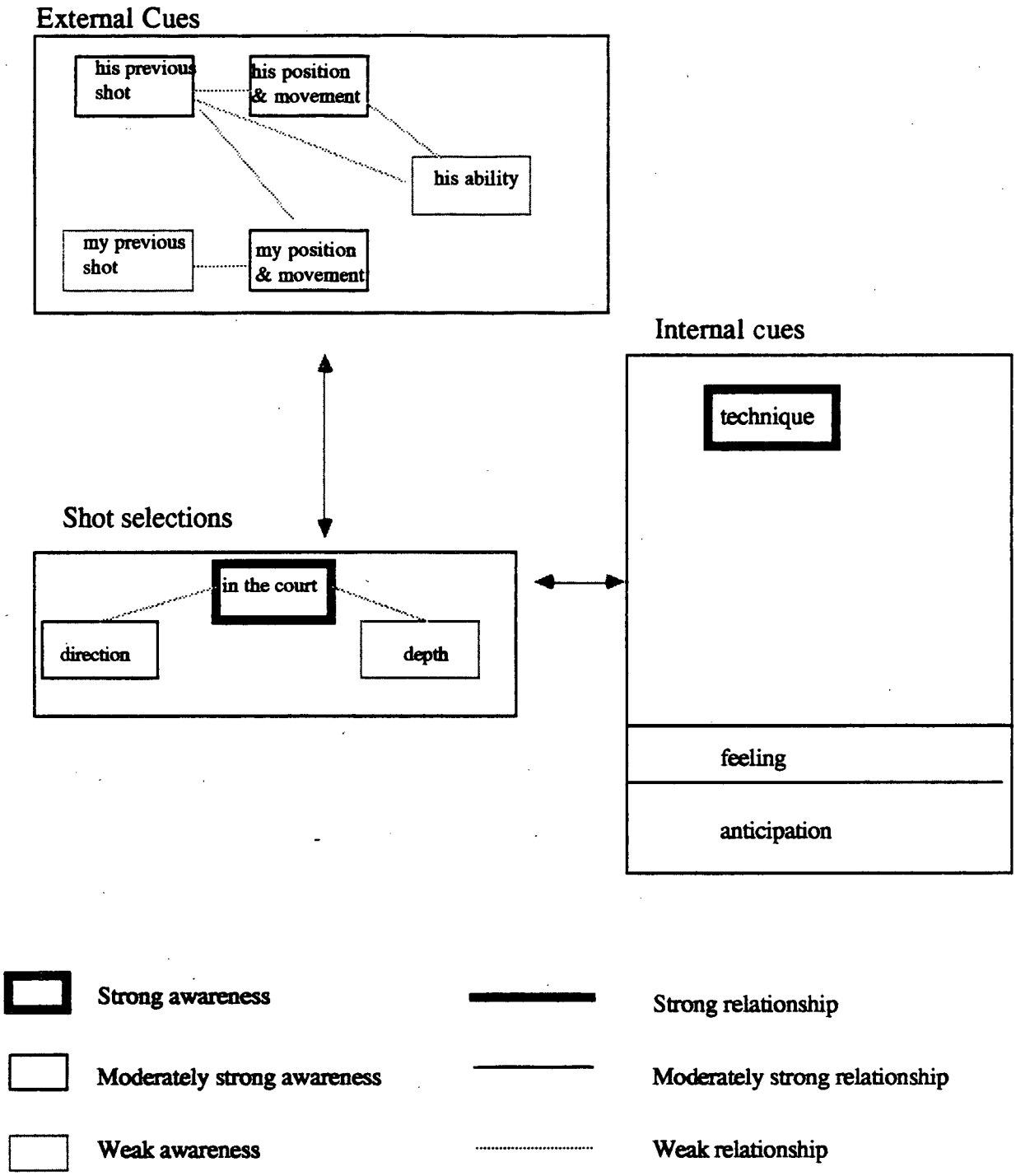
He did not express emotional status toward the game frequently or strongly. Although when the interview began he expressed as the general

feeling of the day in remarking: "Today, I was a bit off." or "I played better than last week", however, the Performance Outcome Summary and video taped performance did not support his expressed general feeling. He did not offer any explanation for these comments: why he felt good or bad on a particular day.

As far as his progression of thoughts during the four-week period is concerned, it seemed that his thoughts on the return of the serves developed to the extent that he could anticipate the opponent's serve (i.e., what kind of serve the opponent is going to deliver) and he intended to direct his returns in certain specified directions. During the rally situation, his thoughts were too occupied with reacting continuously to the on-coming ball to be free to have thoughts on what specific strokes to play. On the contrary, his mind at the moment of serve return, might be more prone to having thoughts on deliberate, directional returns, because it would have, at that moment, less number of external cues to concern itself with, and his mind would be freer to think about what he wanted to do with the serve from his opponent.

Figure 11 shows a diagrammatical summary of S.T.'s verbal reports pattern over the four-week period. As the box of the internal cues attempt to portray, S.T.'s thoughts during the game were engaged with himself, with such matters as detection and correction of his technical errors and inaccurate anticipation. His thoughts relating to the external cues were significantly less frequent than those pertaining to the internal cues. Also, these cues to which he was attending in the situation were in apparent isolation as there was little, if any, evidence of linking or interrelationships. Most of the times during the rally situation he only reacted when the ball was entering his court. The main consideration of

Figure 11. Diagrammatical Summary Player -- S.T. --
-- Relationship between a Player's Shot Selection Decisions and the Operating External Cues and Internal Cues --



his shot was either to just hit it into the court or to intend to hit in a particular direction although it appeared that this directional intention did not contain any tactical thoughts, that is, why he wanted to hit a particular shot. Therefore, it seemed that he did not progress to the point where he could plan to choose a shot ahead of time.

In terms of Anderson's (1982) theory, S.T.'s verbal reports revealed that his knowledge about the game situation remained in the declarative stage in which he was still interpreting the pieces of information in the situation as they occurred or were presented to him. As well, his ability to connect or link the cues in the situation was weak. His prime consideration during the game situation was not with contextual problems such as his opponent's position and movement in relation to himself, but with about "how to" execute appropriate shots with good techniques. Therefore, in his case, composition and proceduralization (Anderson, 1982) of the knowledge about the context was slow or just showing some development.

Using Jewett and Mullan's (1977) taxonomy of the "Movement Process Categories", it could be said that his development was mainly at the "Patterning" stage of movements and his ability to function at the "adapting" stage of movements in the different conditions was not particularly strong. He was approaching the "advanced beginner" stage (Dreyfus & Dreyfus, 1986a,b) in which the performer begins to cope with the real situation although his main consideration was still to follow learned rules.

At the end of the session of the tennis class, his performance was evaluated 2.0 - 2.5 of the National Tennis Rating Program.by the instructor of the course.

4.4. Case Study 4. Player L.P.

L.P., a 21-year-old BPE student, also stated that she had no tennis experience before enrolling in this tennis class. She was also evaluated at 1.0 on the National Tennis Rating Program scale at the beginning of the course. She had three seasons of experience in playing badminton during her elementary and high school years. She also had 11 years of competitive volleyball experience during her elementary and high school years and was a recreational level player as well. In addition, she reported having one year of soccer experience in a community sports club as well as three years of track-and-field experience in high school, reaching a level which qualified her for competition in the Vancouver District and Provincial final competitions. She intends to be a physical education teacher or/and volleyball coach in the future.

L.P.'s responses to the Thought and Performance Development Questionnaire were very positive. She commented that the interview and videotape replay were both very beneficial in the facilitation of her thinking about her tennis games and felt that the joint use of the videotape replay and interview worked very well "hand-in-hand". In her opinion, the videotape replay was more effective than the interview because "you can actually see what you are doing and not what you think you are doing." She reported that the interview made an effective contribution toward the improvement of her tennis game because the interview helped her to become more thoughtful about what she was doing. She commented that continuous use of videotape replay and the interview "may get boring after a while, to do it week after week; but periodically [it's use] is a very good

idea.". She thought that her improvement of tennis skill was due to the increased frequency of her thinking about what she was doing as she had never thought about what she was doing as much as she did during these four weeks. This cognitive involvement with the aid of videotape replay and interview helped her "tremendously" and as a result, she reported, she had improved.

The following is a summary of L.P.'s reports on her performance as interpreted from the transcript of her interview.

Serve

L.P.'s reports on the serve were, in essence, relatively simple. Her thoughts and attention did not communicate the technical or tactical details of what she did. This was true not only on her serve, but also on her rallies and return of the serve.

Of all the thoughts expressed toward the results of her serves, those most frequently offered related to her positive or negative feelings on her performance and they were very simply expressed. The following, for example, is one in which her thoughts showed positive feeling:

> L. At this point I was doing really well. The hitting was coming out right. I was at the right place all the time, even the sound on the racket was really smooth. (1/S/F/3)

And the following, though L.P. did not admit it, seemed to show her negative feeling:

> L. I was not thinking about technique. I was more just commenting to myself that it was a kind of awful wasn't it. (2/S/S/9)

But, on the third day, when she was asked to comment on a good serve, she did not express any elation over the serve. She merely expressed her thoughts on her belief that she had by now progressed to the point where she would expect her serve to go in:

I. What were you thinking after the good serve?
L. Umm, there [I don't] really remember thinking too much because, I guess, I am getting (the serve) in and over more and I'm getting into the court more, like first when I would have more expected it out, you know, I would think, " Oh, great!" (3/S/F/9-11)

She also reported on her "concentration" on the serves. She tried to concentrate on the general "service form" (days 1 and 2) and on "what she was doing" (day 3). Her reports were quite general in nature, not on specific details. For example, on the first day, she reported:

L. Again, just concentrating on form and getting it in. I was getting more confident with my form, and now I was sort of looking more not where I was putting in, but just that I was getting into the court. (1/S/F/4)

It appeared from her report that she was concentrating so much on the serve which totally absorbed her attention that she did not consider any thoughts relating to focus on the coming shots in a rally situation. For example, in the following situation, after her good serve, the opponent hit a short shot. L.P. ran to the ball, and hit a good cross court shot which became a winner. This is how she responded when asked about certain aspects of her playing:

I. That one, he hit a really short shot, and you ran and hit a very good shot. Were you aiming at that direction?
L. That time I don't think I was. It just happened to go that way. I wasn't really thinking where to put it today too much.

I. And were you aware of his position?
L. No, not too much.
I. I see.
L. I find when I was serving, I am concentrating more on what I was doing rather than (on the) ball coming back at me.
I. I see.
L. I still haven't sort of gotten past that. (3/S/S/7)

In her reports, there was very little said about shot selections (i.e., where she wanted to hit) on her serve. In the previous quote, for example, she actually admitted that her good shot was accidental, not the result of shot selection. Only on the first day did she simply report as follows:

L. I was thinking of placing it there, where I was going to put it.(1/S/F.3)

and:

L. I was sort of looking more not where I was putting it, but just that I was getting into the court. (1/S/F/4)

As well, she did not report many thoughts relating to her technical problems. She occasionally mentioned the problems on the back-scratch position, on the over rotating of her torso, and on the tossing motion on her serve. Also she occasionally reported she could not identify why she did well or why she made a particular mistake. For example:

L. Most of them (i.e., her serves) are going well, so I must be doing something right. (2/S/F/6)

L. It wasn't a good serve.
I. Were you aiming at the center or---?
L. No, I was not aiming at the center. I think I was just over rotating or something. I knew I wasn't doing something right. I wasn't sure what. (2/S/S/14)

In summary, her reports on the serve were relatively simple and general. She commented on her feelings related to the results of her serve,

and on trying to concentrate on her service performance to make good serves. But she did not provide many details about what she wanted to do on her serves (i.e., shot selection) or regarding the technical points of her shot execution.

Return of Serves

On the first day, she reported that she did not return the serves well, but from the second day, she indicated that she "felt comfortable" and "felt a lot better".

When she perceived that she was having difficulty in returning the serve, especially on the first day, she attributed the mistakes mainly to a lack of concentration, her slow movement and technical failure. However, she did not describe these problems in precise detail, rather, she reported them simply and generally. For example, in the same manner with which she reflected upon her serves, she talked about the importance of concentration for achieving a good return of the serve:

> L. There, I was thinking about, "O.K., let's concentrate. Let's think about where the ball is coming to." (2/R/F/5)

Also:

> L. Right here, I've started thinking, "O.K., come on, concentrate. Think about what you were doing." (4/R/F/6)

She expressed positive and negative feelings about what she did, especially on the first day and the second day, but not much on the third and the fourth days. Especially on the first day, because she felt she did not return the serve well, her negative self-talk was extensive. For instance:

I. What are you thinking? Do you remember?
L. Not really. Oh, usually my reaction was: "Oh, was that ever awful ! Terrible shot ! What I was doing here, you know, I start to think about where was I---how come I did not get that shot ! I tend to reach slow to the ball, like I wait too long before--- (1/R/S/9)

Nevertheless, occasionally, she also expressed positive feelings, like in the following short outburst of joy on the second day:

L. I was happy with that, "Oh, good ! (chuckle) got him !" (2/R/F/9)

On the second day she also felt more comfortable returning the serves, and her positive feeling was expressed more frequently. For examples:

L That was, I was really happy with that backhand. (2/R/F/6)

And:

L. That one. I was happy with that, put him out of position. (2/R/S/15)

She did not, however, express such feelings on the third and the fourth days as frequently as she did the first two days.

Her thoughts on the anticipation of the opponent's serve (i.e., what kind of serve the opponent is going to hit) were not reported until the interviewer asked her about it (i.e., her anticipation and identification of the serves) on the third day. On the third day, when she was given a question about anticipation, her response was as follows:

I. Now can you anticipate what kind of serve he is going to hit before he starts to hit, or not?
L. No, not really because I sit there thinking, you know, I know, I wonder what kind of serve I am going to get. I never really am too sure. I am not sure what to anticipate. (3/R/F/2)

Similarly, on the same day, questions about the anticipation and identification of the opponent's shot were presented relating to the rallies. These questions seemed to affect her thought and attention with respect to the opponent's serves. On the fourth day, she voluntarily reported the improvement of her anticipation of the serve.

L. I remember I was watching him serve now more, like I was thinking about where the ball would be coming when he was serving?...Like you know how you asked me when I notice that, then I said, "Finally I did something and I got him."
I. Oh, good.
L. Yeah, I've started thinking about,...about I, like I was watching him, and serve, I've started watching where the ball might be coming and I was running a little bit sooner, that's why I did a little bit better there because I could, I was thinking about the ball sooner than when it just crossing the net.
I. I see, so you can react much quicker.
L. Quicker, yeah. Because I could be there before it's coming, whereas usually I am there as it's coming there. (4/R/F/9)

However, she still had difficulty with the recognition of the spin serve. She expressed on the fourth day that:

I. How soon could you anticipate the ball got a lot of spin?
.....
L. Yeah,..it was always when it hit the ground that I realize that, or I don't even know if I realize it was spin, I knew he'd done something to it to make it do that. ..... I think I concentrate more on where it is and where it's coming to. (4/R/S/11)

From the first day, she reported an awareness for the value of direction on her return of serves, and most of the time, she wanted to hit away from him.

In summary, her thoughts were mainly on herself and on her side of the court. She expressed little about the context of the game. She tried to

concentrate on hitting a "good" return of the on-coming serve with sound technique and movements. She did not try to anticipate the kind of serve he was going to hit until she was asked about the matter of anticipation of the opponent's serve. On the fourth day she reported on the analytical benefits of the interview, as she could now identify the on-coming ball earlier than before and could move sooner than before. She expressed her positive and negative thoughts or feelings, especially on the first and the second days, and she expressed less negative self-talk from the second day onward.

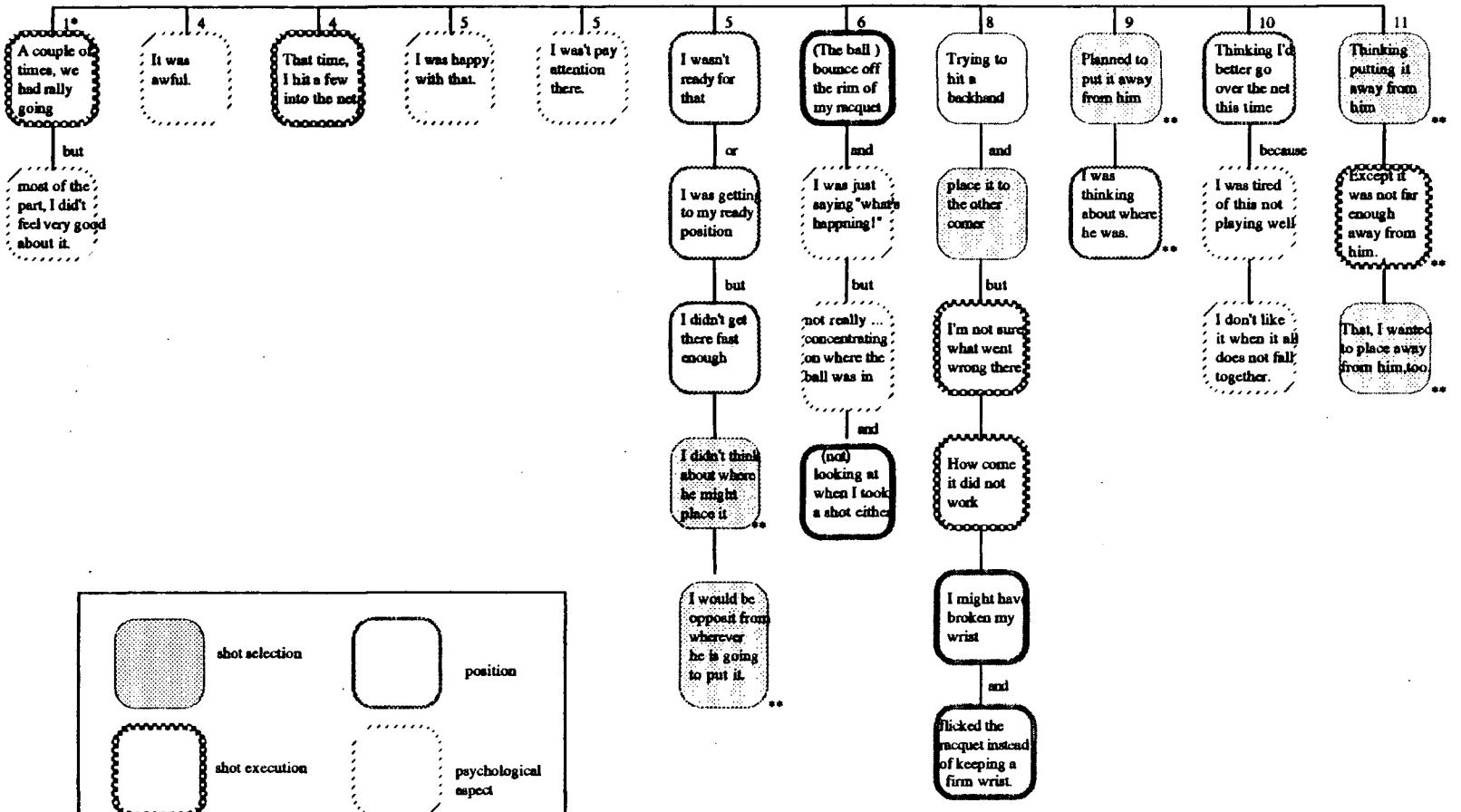
Rallies

Consistent with the descriptions of her serves and returns of serve, L.P.'s thoughts on a particular rally also tended to be relatively short and simple. Figure 12 presents an example of the extent to which cue-linking was evident in her reflections upon her rally situation. There were relatively fewer numbers of situational cues reported and most cues were relatively less linked. Only on the third and fourth days did she express more situational awareness (i.e., more than the first two days) in respect to the intentions of her shot in relation to her opponent. Mainly, her thoughts and attention were internally focused. She attributed her errors mainly to her errors in positioning and movement and to her technical mistakes. When she could not hit shots appropriately during rallies, her representative remarks were of the kind that "I was not in the right position", or "I was not there fast enough". Moreover, when her thoughts were primarily involved with her serve, she reported that she did not concentrate on the ball coming back to her, consequently her preparation was late. For example:

Figure 12. Thought Cue-Linking: (rally situation) Player -- L.P. -- day 3.

* Number = the particular point played

** Comment on the opponent



I. What were you thinking? Were you aware of your position that time?
L. No, not really, I wasn't until afterward, when I realized, you know, I was at the bad position, and I did not have my racquet back, I just wasn't ready for it. See, quite a lot of my shots, I was not quite ready for it, I was not concentrating on the ball coming back. (2/S/S/8)

She seldom reported on her opponent's cues such as his movement and position or his shot selections. These characteristics can be seen in her Frequency of Thought Variables Table (Table 7). The following is a quote from the situation about which, on the second day, she was asked a question about her anticipation:

I. Can you, now think about what kind of shot he is going to hit to you?
L. I still do not think I am really thinking about what he is shooting back to me, I am concentrating on about what I am doing. (2/R/S/15)

On the third day, a similar question was asked when both players were close to the net.

(The situation: After the opponent hit a short shot, L.P. countered with a short shot. Both of them were at the net. Then the opponent hit a lob. L.P. moved back to chase the ball, but her subsequent shot went into the net.)

I. Were you aware of what he was going to do?
L. No, but afterwards I thought, "Well, yeah, of course he's going to send it to, to the back court."
I. From his action, or racket face, or his movement, could you anticipate what he was going to do, or not?
L. No, no.
I. After, actually after he hit the ball, then you thought, "Uh, huh, that's a lob".

Table 7.
Frequency of Thought Variables

Name __ L.P. __

SV= serve, RL= rally, TL= total
Number in O = negative remark

	day 1			day 2			day 3			day 4		
	SV	RL	TL	SV	RL	TL	SV	RL	TL	SV	RL	TL
1. Feeling												
Emotional cont'l-Arousal											1	1
-Thought	3	3 (0)	6 (0)	3 (6)	1 (0)	4 (0)	(0)	3 (5)	3 (6)	1 (0)	1 (3)	2 (4)
Attention cont'l-Concent'n	2		2	4	1 (0)	5 (0)	1 (0)	(5)	1 (6)	2 (0)	1	3 (0)
Mental practice												
2. Planning for today												
3. Input relevant cues												
the ball movement								1 (2)	1 (2)		1	1
his movement & position		1	1					1	1		(0)	(0)
his shot selection								1	1			
his shot execution												
my movement & position		5 (2)	5 (2)					1 (2)	1 (2)		3	3
anticipation		1 (0)	1 (0)		(0)	(0)		(0)	(0)		2	2
4. Response selection												
in the court		1	1	1	1	2					1	1
direction	2	2 (0)	4 (0)					3	3		3 (0)	3 (0)
depth												
height												
spin												
speed												
offensiveness												
defensiveness (rally going)												
strategies (shots ahead)												
5. My response execution												
good	2	1	3	3		3	1	2	3	1	2	3
out/not intended				3	1	4		3	3	2	2	4
6. Analyzing												
my technique	1	1	2	3 (0)	1 (0)	4 (3)	1 (2)	2 (0)	3 (3)	1 (0)	1 (2)	2 (3)
my shot selection												
my level							1		1			
his level												
7. Evaluating												
what I did (good, bad)		1	1	2	1	3		1	1	2 (0)	(0)	2 (2)
I did not know what to do								2	2			
I could should) have –		2	2	(0)		(0)						
He could have –												
8. General comment					1	1					3	3
9. Off task thought								3	3		1	1
		(5)	(5)	(8)	(4)	(12)	(4)	(14)	(20)	(4)	(8)	(12)
Total	10	18	28	19	7	26	4	23	27	9	22	31
performance results												
1st serve in	8/14			9/15			6/11			3/10		
2nd serve in	4/5			2/6			4/5			4/7		
Rallies: total/ x=	56 / x=43			36 / x=2.92			53 / x=4.82			39 / x=3.9		
won/lost	2/11			2/13			1/10			1/9		

L. Yeah, yeah, but before that, I wasn't watching him what he'll be doing.
I. Were you aware of his position and your position?
L. Yeah, I was aware of we were both up there, but I did not think how or what would become of that.
I. Generally before he hit the shot, could you tell what kind of shot he is going to hit, or not?
L. No, no. I don't concentrate on. (3/R/S/11)

So it appears that her analysis did not include anticipation of the coming situation. On the fourth day, when she was asked how soon could she identify the ball coming to a certain direction, she reported:

L. I think it's when it crosses the net that I finally realize where it is coming, and I'm going to which hand I'm going to get, I am going to have to use backhand or forehand.
I. I see.
L. So I don't think I clue in too soon, it's when it crosses the net I realize. (I. I see.) Because I'm never, never watching him and what his racquet is doing, and which way he is hitting it. (4/S/S/10)

However, on another occasion on the fourth day, she reported she was thinking more about the opponent's position.

From the first day, she reported her intention to hit the ball in a particular direction. Such direction-oriented intentional hits were even more numerous on the third and the fourth days. Most of the time her intentions were "to hit the ball away from him", or "to place the ball"; however, she rarely mentioned about any relationship among the external cues such as the opponent's shot and her position. When she had a long rally, she seemed to enjoy it, and she expressed her positive feeling by such words as : "feel good"; "confident"; "calm". On the other hand, she expressed strong negative self-talk when she made unforced errors.

Also on the third and the fourth days, she reported the differences between the games played as the server and those played as the receiver. During the games played as the receiver, she reported she could feel better than when she was the server. She also could think more tactically as a receiver:

I. How was your return of his serve?
L. It was actually going a lot better, I feel, I can play a lot better when I don't have to serve. (3/R/F/G)

She expressed a similar thought in the following quote:

L. ...but I found when I was receiving, I can think more about where I want to put the ball, and keep it away from him. ((3/R/F/8)

And she commented on her inability to think tactically when she was serving, in the following quote:

I. Were you aware of his position and the direction of his shot?
L. Yeah, yeah, I was thinking about where he was because I was placing away from him more out, you know; I was thinking about where it should go.
I. I see.
L. When I was serving, I wasn't thinking about that, because I was too busy thinking about my serve. (4/R/S/15)

Actually, her incidents of positive thought about her rally in her receiving games were more frequent than in the serving games.

In summary, her thoughts on the rally situation were mainly on internal cues and she did not focus on her opponent very much. She attributed her mistakes during the rally to her technical errors and her slow reaction and position. She had the intention of hitting the ball in a certain direction, but most of the time she did not comment on the relation

of such intentions to her observations of the opponent's position or movement or shot selection. Her reports of her directionally oriented intentional shots were simple: she did not say much other than simply wanting to hit the ball in a certain direction. She expressed her thoughts on the rally situation as those of feeling good on the long rallies and, in the receiving game, she reported the thought that she did not experience the tension associated with the situation when she was playing the serving games.

General Summary

L.P.'s thoughts and attention were primarily focused on her internal cues. She reported very seldom on cues associated with her opponent such as his position, movement and shot selections. Her thoughts were mainly on how she felt, what she was trying to do and what she did. She reported, besides her intention of just hitting into the court, her intention to hit her shots in certain specific directions as well. However, these directionally oriented and intentional strokes did not appear to have a linkage to the opponent's position and movement. From the first day, she reported that she was trying to hit in a certain direction. This intention seemed to become stronger on the third and the fourth days, especially on her return of the serve and during rallies especially. However, she did not at any time report any attempts to hit shots with other qualities, such as depth and spin.

She often mentioned that she did not pay attention to what her opponent was doing. Therefore, her focus in the situation seemed to be mainly on her side of the court. The opponent and his side of the court seemed to feature very weakly in her schema. This may have occurred because she did not give any thought to anticipating what the opponent did

until she was asked during the interview. In addition, she often had problem with taking a good position to hit a good shot because of her late identification of the characteristics of the on-coming ball.

When she played as the server, she really had to concentrate on the serve; therefore, she frequently reported that she was not paying attention to the on-coming ball. However, in her service return game, she did not express the necessity of such intense concentration as needed in the serving games. It seems that it was difficult for her to switch the thought and attention from serve (as closed skill) to the ensuing rally (as open skill). From her report, we can infer that she had difficulty extending her scope of attention to encompass the entire court. This limited scope of attention was especially noticeable when she, after serving, would show a delay as she completed switching of attention, from herself to include her opponent in the ensuing rally. However, when she played the receiving game, she could start the game focusing on the on-coming ball, and she could continue to the ensuing rally much more smoothly without a lapse in concentration.

She attributed her errors mainly to late preparation and technical faults, but she did not analyze the causes of the errors too deeply. She also reported off-task thoughts like school work, which bothered her concentration on the game on the third and fourth day.

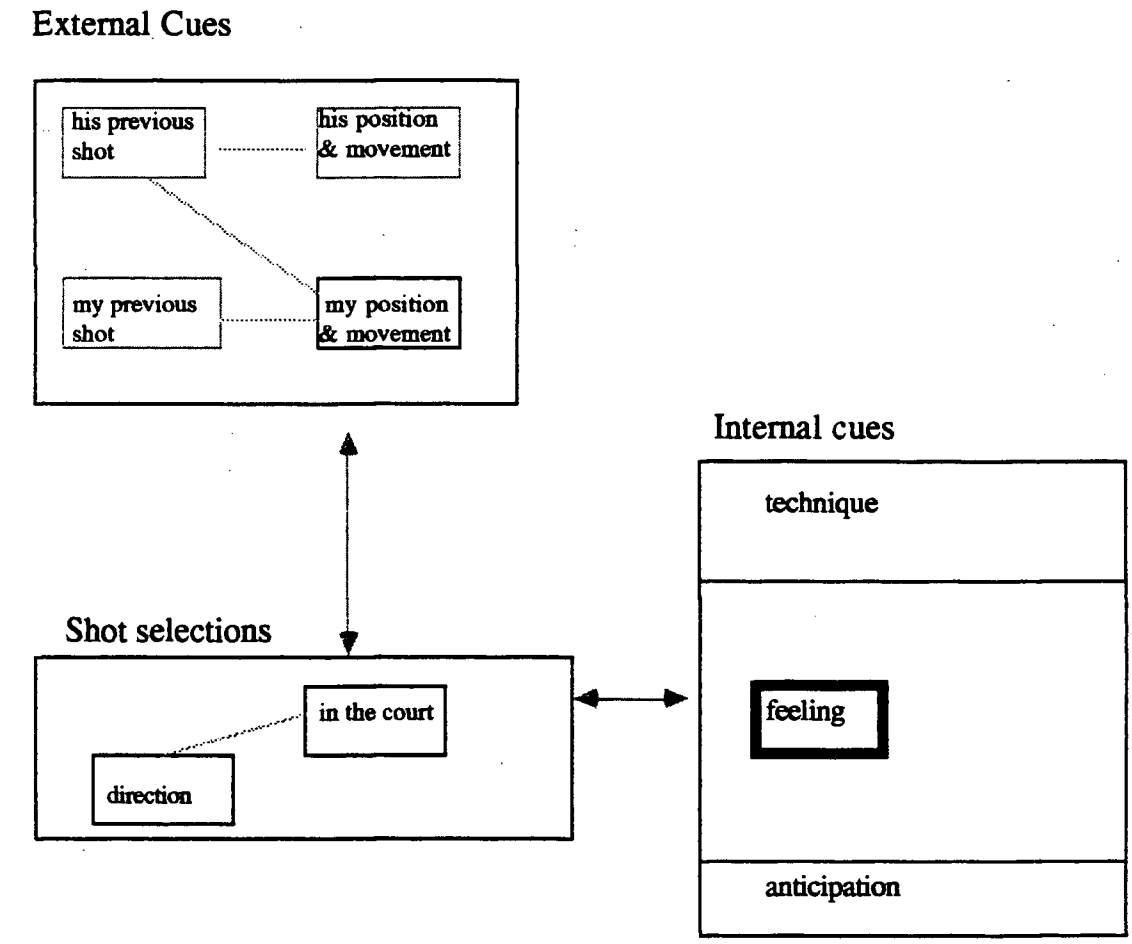
The other characteristics of her reports were that they were often of a negative nature (e.g., "I was not aware of my position"; "I was not concentrating on the ball coming back to me"). It is not clear at this moment what this means. It could be that (1) she knew what to do in theory, but could not actually do it; (2) it was just the habitual mode of her way of thinking.

She reported improvement of her performance during the interview as well as in her response to the Thought and Performance Development Questionnaire. Her verbal reports indicated that her performance had improved especially in terms of a stronger purposefulness behind her directional shots, as well as in her becoming increasingly aware of the concept of anticipation of her opponent's shots.

Figure 13 diagrammatically presents a summary of L.P.'s thoughts based on her verbal reports. As far as internal cues are concerned, she was often given to emotional expressions. Her thoughts on the technical analysis of her shots were not frequently offered and she was not particularly concerned about anticipation (i.e.,where and what to look for in the situation). Therefore, her thoughts on her internal cues, other than on her emotions, were not strong as well.

Her thoughts relevant to the external cues, especially those involving her opponent, were weak and the relationships among the cues were likewise weak. In general, we could infer that her thoughts related to the game situation were just starting to develop, and she was becoming aware of some of the situational cues. She admitted that the interview and video tape helped her to recognize and use the important cues in the situation. Also she began to think about her shot selections in relation to the context. However, it seems that her knowledge about the context of the tennis game was not well developed and had not been proceduralized to any effective degree. Any reference to information relating to the context existed as separate pieces and were not considered as being particularly related. The interpretation of pieces of information (Anderson,1982) caused the delay and unsmoothness of her shot execution and led to many errors.

Figure 13. Diagrammatical Summary Player -- L.P. -- -- Relationship between a Player's Shot Selection Decisions and the Operating External Cues and Internal Cues --



In the stages described by Dreyfus and Dreyfus (1986a,b,) she is in the early stage of "advanced beginner"'s category where her performance is best considered as "context-free" with some situational thoughts becoming apparent. In her case, her knowledge of tennis game is mainly in the declarative stage (Anderson, 1982) and perhaps only a small quantity of this declarative knowledge was being actually compiled and proceduralized in her working memory in the context of the game situation. She was also at the "patterning" and "adapting" stage in the game situation categorized by Jewett and Mullan (1977).

Her performance was evaluated as 2.0 - 2.5 on the National Tennis Rating Program by the instructor at the end of the session of this tennis class.

5. MULTIPLE CASE REPORTS AND CONCLUSION

The characteristics and developmental features of four novice tennis players' thought processes and knowledge structures were explored over a four-week period of tennis game play, using the method of stimulated recall with the aid of video tape replay in the multiple case study approach. The basic purpose of this study was, for pedagogical reasons, to better understand the development of novice performers' knowledge structure by the examination of their thought processes in action. The focus was to attend to the real game situation in which the players perceived and thought while interacting with the environment. (Neisser,1976). The multiple case study approach revealed a variety of interesting findings relative to the study questions which stimulated this research. These questions were:

1. What patterns of knowledge organization exhibit themselves in the self reports of the novice players?
2. Is there a relationship between novice knowledge structure, as derived from the nature of the thought processes, and the playing ability at this level?
3. Are individual differences in thought processes and knowledge structures apparent over the period of four weeks?

It is appropriate to state that, in light of the small sample size and the fact that the participants of this study were not randomly selected, it is not possible to generalize the findings of this study. However, we can now speculate in a more informed manner on the characteristics of knowledge structure and thought processes of novice tennis players and their development based on this multiple case study investigation.

The following multiple case reports have two sections. The first section is related to study questions 1 and 2 and is discussed as "common themes among the four novices --thought patterns and knowledge structures in relation to playing ability". It was revealed that the pattern of the knowledge structure of the novices and their playing ability were interrelated and, consequently, these should be discussed together. The second section is about "individual differences among the four players" as reflected in the answer to study question 3.

5.1. Common Themes among the Four Novices --Thought patterns and knowledge structures in relation to playing ability.--

First of all, it should be mentioned that, among the four players, C.A presented somewhat different characteristics from the other players with regard to her verbal reports. Her performance outcome as recorded in the CompuTennis score sheets also suggested that her performance capability progressed to a slightly higher level than that of the other players. On the whole, she could maintain longer rallies and committed fewer double faults during the games. Also C.A.'s final performance level was evaluated by the instructor as 3.0-3.5 according to the National Tennis Rating Program (NTRP) as compared to the other players' final evaluations in the range of between 2.0- 3.0. Generally, her verbal reports were more situationally oriented, containing a more frequent expression of shot selection comments than the others. However, as a player who had only six weeks of instruction, C.A. also demonstrated some characteristics in her thought processes and knowledge structures similar to those of the other novice

players. For example, like the other three players, her anticipation of the opponent's variety of shots, such as the spin serve, was not well developed and her verbal reports indicated that she was trying to read and interpret the situation and organize a functional relationship between herself and the on-coming ball. Thus, the following is mainly a discussion of C.A. in contrast with the other three players, complemented by a discussion of similarities found to exist among all four players.

The verbal reports presented similarities among all the four players that could be categorized into the following areas: (a) the relationship among the external cues and the shot selection decision by the players, (b) their internal cues during the game situation, and (c) the relationship between the on-coming ball and the players' reaction and attention to it.

5.1.1. The relationship among the external cues and the shot selection decision by the players

One of the important findings in this study was the nature of the relationship among the external cues which the novice players reported. As is shown in the diagrams (Figure 7, 9a, 9b, 11, 13 in page 91, 109, 110, 128, 146 accordingly) which are presented as the summaries of the players' verbal report, external cues, such as, the opponent's previous shot, his position and movement, and the player's own position and movement did not frequently appear in the expression of the novice thought processes. Moreover, these external cues themselves were weakly interrelated as if they existed as separate entities.

In addition to comments relating to the external cues, especially the opponent's movement, their verbal reports also dealt with their shot

selection decisions, which revealed that they possessed a limited variety. This fact indicated that not only were the players unable to execute the various shots, but also that they had not yet developed a schema of what characteristics to look for in the various game situations. Therefore, as their verbal reports indicated, the players did not have many options of their shot selection in relation to the opponent's performance. Their verbal reports revealed mainly a concern for merely hitting the ball in the court, plus, on occasion, some measure of a directional intention. Only R.M. in the last stage of the study and C.A. reported more extensive shot selections and intentions in relation to the external cues.

It seemed that the ability to recognize the variety of external cues with functional relationships among them in a player's knowledge structures corresponded to the development of the quality of a player's shot selections. The production rules (Anderson, 1982; Chi, 1987) can explain this situation. The condition side (IF), which consists of a variety of external conditions, and the action side (THEN), which consists of a variety of shot selections in the present study, meet and develop correspondingly. Through the accumulation of playing experience, a novice's schema seems to develop to include various solutions that can be utilized in recognized game contexts and thus he/she progresses to develop more production systems. In other words, the employment of the knowledge of the context in turn facilitates the organization and accessibility of the stored knowledge in particular situations (Tennison & Rasch, 1988). In the present study, the novice players frequently reported the shot selection without any reference to any cue on the condition side (e.g., hitting a shot without considering the opponent's position); therefore, they could not comment on the strategic solutions during the game situations.

Similarly, Chi, Feltovich and Glaser (1981) revealed in their study on physics problem solving that "their (novices') action can be characterized more as attempts to find specific unknowns, such as 'find the mass'" (p. 140). Moreover they found that one of the novices "exhibited a number of production rules that have no explicit actions" (p.140). This was also identified in the present study. The novice tennis players sometimes were aware of the condition (e.g., the opponent was at the net position), however, they might fail to adopt the action demanded by such conditions (e.g., they merely tried to return the shot into the court without attempting a lob or a passing shot.) Therefore, as the present study and the study by Chi, Feltovich and Glaser (1981) demonstrated, the novices sometimes take action within the framework of incomplete production systems, with either only the condition side or only the action side being operative. In spite of this similarity in both studies, however, we should also be aware of certain differences due to the different nature inherent in the tennis skill performance and the pure cognitive skill tasks: in the tennis situation, the player had to react immediately to a condition, whereas in the cognitive skill situation the person was not compelled to react. In the present study, C.A. and the final stage of R.M. presented a greater variety of the functional relationships between the external cues and their shot selections. Although their procedural knowledge (production rules) was rather simple, they nevertheless presented a more complete form of the productions. It seems that as skill acquisition progresses, a player compiles and composes the information in the situation and possesses many production rules which are organized to direct action appropriately in particular situations (Anderson,1982,1985). Therefore, it is speculated that expert tennis players probably possess more refined and a greater variety

of production rules (procedural knowledge) between the external cues and shot selection, and, moreover, these cues have a robust relationship among them. Further research with expert competitors is needed to confirm the speculation of the experts' thought processes and their knowledge organization.

5.1.2. The players' internal cues during the games

As novice players, their thoughts frequently were concerned with technical correction of tennis skills as well as with their emotional states, especially after the players had made what they perceived to be an error. Among the four players, only C.A. did not show much expression of emotions or preoccupation with technical corrections. However, she reported that she would think about technical corrections when she could not "hit good serves" or when she was learning a new skill. The other three players, especially R.M. and S.T. often talked about their technical concern and corrections during the interview. At this stage, the execution of the proper technique which they had learned (e.g., how to hit good serves) still did not seem to be well proceduralized, and they had to consciously perceive and pattern (Jewett & Mullan, 1977) the proper technique in the game situation. As well, it appeared that S.T.'s extensive, if not excessive, analysis of his technique appeared to have caused some problems in his ability to focus his attention on the external cues present.

The other important finding about the novices was that of the problem of transition from the serve to rally situation. Except C.A., the other three players all had difficulty on smooth transition from the "closed skill" serve to the "open skill" rally situation. "Getting the serve in" with

appropriate technique seemed to demand total attentional focus and appeared to be stressful at this stage. They commented that they could focus on situational cues much more and felt less pressure when they started the game as receivers.

Expressions of emotion were reported frequently by R.M. and L.P.. Their negative self-talk was mainly generated by their performance errors. Especially, the errors on service delivery were related most frequently to their negative emotional status compared with return of serve and following rally situation. Their positive thoughts toward themselves were mainly connected with long rallies and/or clean winners or good forcing shots. It seemed that, when they reported negative self-talk, their attention had shifted to their technical inadequacies and when they reported positive feeling, the attention was upon the external cues and shot selection decisions. Lohman(1989) suggested that intelligence (cognitive), emotion (affective) and intention (conative) are all interrelated in order for the human being to develop their intelligence. In light of the findings of this study, we are once again reminded to take into consideration the players' state of emotional control in order to maximize their performance outcome which typically focuses on the strategic skills with appropriate technique.

In summary, the players at this stage seemed to attend primarily to their internal cues such as technical stroke problems and their feelings toward the game and themselves. As far as technical cues are concerned, at this stage, their attention was on "how to hit good shots" with appropriate techniques. This stage is clearly described as the "advanced beginner" stage by Dreyfus and Dreyfus (1986a,b). At this stage, the advanced beginners are still trying to follow the "context-free rules" which they have learned, although they have started to cope with the situational context. The novice

players in the present study might be aware of the cues in the situation, but they were unable to link the cues in a more functional way. Jewett and Mullan(1977) also describe this stage as one in which there is "patterning" and "adapting" in the movements.

Many researchers also indicate that when students have negative thoughts toward themselves, it seems to lower their achievement and attitudes (Kirschembaum & Wittrock, 1984; Wittrock, 1986). Kirschembaum and Wittrock (1984) state that:

> ....., studies of differential self-monitoring (positive vs. negative self-monitoring) have also shown that thinking about one's failures (negative self-monitoring) often interferes with performance of poorly mastered task (p. 86).

Therefore, they suggest the intervention of attention focus to reduce negative affect when difficult tasks are being performed. On the other hand, if the tasks are well mastered and highly routinized, negative self-monitoring (e.g., recording errors and problems) will facilitate their achievement.

5.1.3. The relationships between the on-coming ball and the players' reaction and attention to it

Another important finding relates to the way the player reacts toward the on-coming ball. The players reported that they reacted when the ball was coming toward their court or when the ball crossed the net. During the rallies, the players often could not anticipate the kind of shot the opponent was going to hit and they reacted to the on-coming ball only after

it had been hit and was well on its way to them. However, when the players were receiving the opponent's serve, most of them could quite quickly determine the characteristics of the serve such as its direction and spin. Because the composition and proceduralization process of information in the context had not been well progressed, their working memory capacity apparently could not accept all the information from the environment while rallying the ball, therefore, the delay of the reaction occurred.

In the previous description of the external cues in relation to the players shot selections, the players, except for C.A. and also R.M. in the final stage of this study, reported limited variety in their shot selection decisions relative to the variety of the external cues present. This feature could be explained by their narrow focus, mainly on the on-coming ball itself without being aware of the broad context within which the ball was being delivered (i.e., why it was selected and/or how it was executed). As it was discussed in the previous section, the action (THEN) side was taken without the consideration of the condition(IF) side. With their limited awareness of the context and the planning of their responding shot, the players seemed to react to the immediate on-coming ball only with the purpose of returning it to the opponent's court. Their verbal reports (especially by S.T. and L.P.) revealed that it seemed that the thoughts relating to the coming ball, to the opponent and to the shot executed by them all existed as disjointed entities, not associated with one another. The reaction was, therefore, generally with little, if any, strategic thought, such as to think of returning the shot to a particular side of the opponent's court. As well, their late perception of the quality of the on-coming ball often caused a delay in the preparation required to return the ball. At their level,

it appeared to be an especially difficult task to identify the spin on the shot, whereas the direction of the shot was relatively simple for them to identify. When the opponent's shot contained the possibility of several different kinds of spin (e.g., top spin and underspin), with the additional possibility of a wide range of speed and depth, the players seemed to inadequate in decisions relating to the proper position on the court and the appropriate move to get to it.

These characteristics of our novice players are contrasted with those pertaining to the novices in the study of physics problem-solving by Chi, Feltovich and Glaser (1981). Their study showed that the novices were more "surface-oriented" and that they organized categories of physics problems by literal objects stated in the problem description. The present study and their study showed that the novices did not possess procedural knowledge about the deep structure of the context and dealt with the problems by their immediate surface features.

In summary, the characteristics of the novice tennis players in this study were that their awareness of the external cues was generally weak, and also that these cues were not meaningfully linked to each other. Their shot selection also did not reveal much variety in relation to the existing situational context such as the opponent's position, movement and previous shot. In other words, they possessed very simple production rules or incomplete production rules either with only the condition side or only the action side operating. The novices' considerations were mainly focused on internal thoughts, such as, concentrating on techniques to execute the proper strokes and on their personal feelings. They reacted mainly to the immediate on-coming ball as a result of the inability to anticipate it,

therefore they were often slow in making the proper preparations. Among the four players, however, C.A. reported at a higher level of performance characteristics than the other three players. She developed an awareness for more external cues, focussed less on her internal cues and developed a greater variety of shots. R.M. demonstrated greatest progression and development over the duration of the study. The differences among the four players in their thought processes and knowledge structures were definitely apparent but were indicative of being consistent with the various stages in the progressive nature of skill development. As the understanding of context develops and the employment of procedural knowledge progresses in the context, the novice players' performance capabilities improve.

The findings of the novice patterns in this study can be further compared with the novice- expert study by Housner (1981) with certain recognizable similarities. Housner's (1981) study on novice-expert badminton players, especially, presents some interesting similarities to this study. First, both studies revealed that the novice player did not report many strategic concepts and those strategic concepts which were reported were of rather simple form. In Housner's study, the expert subject demonstrated the ability to chunk pertinent information into summary statements. In the present study, this ability was observed when a player's comments contained situational cues with the linking of shot selection cues, and these situational cues formed the conditions leading toward specific shot selection for the next stroke. Although C.A. did not demonstrate a highly refined performance level, and her strategies were not of complex form, her verbal reports revealed a functional linking between situational

cues and shot selection decisions and more production rules. She was, in effect, demonstrating the ability to chunk pertinent information. On the other hand, the other players, like Housner's novice subject, reported only simple shot selection decisions, such as, hitting the ball to the place where the opponent was not.

Second, both studies disclosed that the novices had limited number of interconnections between the concepts. Housner presented two figures which portrayed his conception of a representative knowledge structure of a novice and an expert badminton players (Figure 1a,1b in page 26). These figures revealed Housner's interpretation of how the strategic concepts appeared to be organized in the players' knowledge structures. However, these representations did not provide any indication related to the depth and breadth of the concepts and, especially, the relationships among the concepts in the same level. Moreover, the concepts presented under shot selection did not indicate interrelations with other relevant factors.

The present study's procedures permitted a more complete representation in its presentation of diagrammatic summaries (Figure 7, 9a, 9b, 11, 13) of the four subjects' thought processes and knowledge structures. They were portrayed as developing qualitatively (i.e., development of the breadth and depth of the cues and intensity of interrelationship among the cues) as well as quantitatively (i.e., number of the cues processed). For example, R.M.'s development (Figure 9a, 9b) indicated a growth in the number of cues being attended to as well as the expansion and strengthening of the relationship among the cues in both the analysis of the external context and the appropriateness of his corresponding shot selections during the four week period. Therefore, the advantages of this type of presentation or analysis is that it provides:

1. A representation of the depth and breadth of the relevant concepts and their interrelationships.
2. A representation of the growth of the knowledge structures.
3. A representation of not only the knowledge structure, but also the associated thought processes to indicate the relevance of the player's attentional focus, cue selection and decision making activity.
4. A basis for the comparison of individual differences in concept development (e.g., development of cue processing in shot selection; development of cue awareness in the external context) among the players at similar playing level as well as at different playing levels.

5.2. Individual Differences among the Four players

Although the subjects had virtually very limited tennis experience before the tennis course, and they received the same instruction during this course, individual differences were, nevertheless, continuously detected in the verbal reports during the study. There were two aspects of individual differences which were revealed among the four players: (1) the degree of progression of thought processes and knowledge structure, (2) attention focus in their performance and the stored knowledge which the player employed during the game.

First of all, although all the four players commented that their performance had improved during the four weeks, generally, the degree of progression of thought processes and knowledge structures in the game situation varied among the four players during the four weeks of this study. For example, R.M. revealed extensive development in his external cue

awareness in relation to his shot selection. S.T. and L.P. demonstrated a strengthening of a particular isolated performance factor (i.e., anticipation of the opponent's serve by S.T.; directional intention of shot selection by L.P). C.A. did not exhibit observable progression during the four weeks. The apparent discrepancy between her subjective perception revealed by the Thought and Performance Development Questionnaire and other more tangible ways of assessment may perhaps be interpreted in the following two ways: (1) The four weeks of this study were too short to expect noticeable progression of thought processes and development of knowledge structures at her stage of proficiency; (2) The focus on the cues in a game situation (e.g., various opponent cues) may not change or develop so quickly at her stage. Rather, any qualitative change at her stage of the compilation and proceduralization through the practice may be a slow process. These reasons could account for the appareent lack of progression revealed in C.A.'s verbal reports through the interview.

Secondly, the differences in the attention focus: C.A. reported more on cues related to her opponent than to herself. Her verbal report also contained more variety of shot selection and strategic cues than did the other players. She did not express her emotion so much. Her reports on the technical cues were very limited and her reports presented more complex thought processes and knowledge structures than did the other players. It would be interesting to know the nature of her responses, at the time when she just started to play tennis games, to questions such as whether she paid attention more to technique-related internal cues or to situational cues which might well have been acquired during her related sports experiences.

S.T., on the other hand, reported extensively on many internal cues, especially his technical corrections, during the four weeks. His thoughts often dwelled on some detailed analysis of his techniques, and he paid very limited attention on the game's situational cues.

Similarly, for the most part, L.P. did not comment on the opponent's cues. She reported often about how she felt and whether she did well or poorly. She commented that she did not think about what she wanted to do or what she had to do during the game.

R.M. reported on the widest range of cues among the four players: internal cues such as feelings and techniques; external cues such as opponent's movements and position and some cues pertaining to strategic points.

The utilization of stored knowledge which the players employed during the game also indicated the individual differences among the four players. Their verbal reports indicated that they possessed different degrees of strength of the linkage among these cues. Of course, this aspect of differences among the players is strongly related to the players' attention focus described above. Kyllonen & Christal (1989) suggested that the measurement of individual differences on cognitive skills could be assessed from four primary sources: (1) information processing efficiency (i.e., speed), (2) working memory capacity (i. e., processing workspace or/and activation capacity), (3) depth (i.e., the amount of domain specific knowledge), breadth (i.e., the amount of general factual knowledge), accessibility and organization of declarative knowledge and (4) depth, breath, accessibility and organization of procedural and strategic skills. Actually, this paradigm of individual differences fit the case-study findings of this study very well. The diagrammatic summary of the four players in

this study indicates that the players' depth, breath and pattern of declarative and procedural knowledge are mediated by the players' working memory capacity and information processing efficiency.

6. PEDAGOGICAL IMPLICATIONS AND SUGGESTIONS FOR FUTURE STUDY

6.1. Pedagogical Implications

These case studies vividly present the novice players' knowledge structures and thought processes in relation to their playing abilities. As the knowledge structures and thought processes mediate between the instruction and the performance (Wittrock, 1986; Weinstein & Mayer, 1986), it is essential to teachers/coaches to understand how a player processes information and how they organize and develop their schema. Chi and Glaser (1980) commented that:

> "Lack of knowledge of the phases of development of complex performance can result in educational conditions that place artificial limits on performance that serve as detriments to the learning of advanced competence. In an instructional situation, individuals can cease to show improvement not because they are incapable of further learning, but because some conditions of performance imposed by instruction restrict the opportunity for the development of expertise." (p. 46)

The findings of this study and the processes employed to obtain them have various implications for sport skill instruction, especially for the performance of open skills.

First, this study supports existing studies in stressing the importance of understanding learners' thought processes and knowledge structures in order to provide effective instruction. The novice players in this study exhibited a variety of individual differences as well as similar characteristics at their level. Thus, the same instruction can be processed and organized by different players in a variety of ways as influenced by

their individual background, interest, capacity and specific ways of processing information and the structuring of knowledge in their knowledge system. In order to facilitate a novice's skill learning, the instructor should closely monitor the appropriate cues by observing how the new knowledge is integrated into the old knowledge. Take the discussion of teaching new models in theories as an example, Wittrock (1986) commented that:

> The teaching of new models or theories presents a complex problem that also involves the students' organized knowledge and experience. The research we have discussed implies that the learning of a new perspective or model involves the relearning or accommodation of a previously learned conception. Knowledge of that conception is a first step, but only that, toward designing instruction which must do more than simply teach the difference between students' beliefs and teachers' knowledge. The instruction should facilitate the construction of a new conceptual framework from an old preconception (p. 309).

For example, in S.T.'s case, it is important for him to develop more situationally oriented thoughts during the game while he is working on his technical errors and corrections. In L.P.'s case, it is important to guide her to apply her knowledge appropriately and to increase her procedural knowledge in the game situation by means of monitoring her own performance and enlarging and deepening her knowledge about the context: when and why to do certain actions during the game situation. Moreover, she and R.M. should be guided on the question of emotional control during the performance, for their emotional status had affected their performance. They could be guided to focus more on the positive cues on their performance in order to achieve their optimal performance. C.A.'s instruction should direct her learning to more variety in her strategic skills

while refining her various shot techniques as well as developing her perceptual skills (e.g., detection of the opponent's weaknesses and strengths)

The second implication emerges from the realization that three players in this study reported having difficulty maintaining steady concentration in the transition from the serve (closed skill) to the rally situation (open skill). As novice players, "getting the serve in" with appropriate technique seemed to demand so much effort in concentration as to make it difficult for them to sustain their concentration and make the transition to the subsequent rally. These players reported that they could focus on the situational cues much more successfully when they started as receivers. In order to enable the novice players to make smooth transition from the serve to rally without disrupting the development, ultimately, of the techniques for a proper service, it is recommended that a modified form of serve and/or game should be considered to make this task easier for the novice players. The modifications of the service for novices to be considered may include the following aspects:

1. Modified service technique (e.g., half-swing form starting from the back-scratch position).
2. Enlarging the service court area.
3. Increasing the number of trials permitted on the serve (e.g., three to four service chances instead of the normal two).
4. Using underhand serve (i.e., groundstroke technique without bouncing the ball).

However, effort should be made to provide the most effective instruction for novice players to perform the proper service technique in game play in the regulated service court as early as possible.

Third, from the findings of this study, we can infer the development of a tennis knowledge structure in relation to the context of game situation. The verbal reports presented in this study have provided an indication of how elements of information were processed by these players; of how knowledge was compiled and organized, and how the players' schema grew as a result of increasing of experience and the development of playing ability. During the study, the progression of a player's performance could not so readily and immediately be observed; however, the verbal reports appear to indicate that during that period the player must have been developing his/her schema of the game. These facts lead us to speculate -- and other novice-expert studies tend to support us in this regard -- on how novice tennis players' schema expands with respect to it's depth, breadth, accessibility and organization as one proceeds to become an expert player. More specifically, the present study showed that a developing schema would progressively incorporate more external and shot selection cues, and these cues would become more tightly interconnected and would always be accessible to the working memory. Thus effective instruction should include devising a procedure for actively and intentionally involving the novice in the development of his/her own schema which contains the appropriate procedural knowledge for his/her performance level.

The final implication is that the Thought and Performance Development Questionnaire given to the four players at the conclusion of the stimulated recall sessions indicated that the interview with video tape replay produced very positive effects on the players' cognitive involvement and, consequently, on their performance. While all the four players reported that the interview with the video tape replay helped them to think more analytically about their games, two players felt that the video tape

replay was more effective than the interview. One player felt that the interview was more effective than the video and one player felt that the most effective way was a combination of the interview and the video tape replay.

These responses to the Questionnaire indicated that these two methods were beneficial to the facilitation of the learning process and they enhanced the outcome. By using them, an instructor can more surely guide players to attend to particular aspects of performance and, if necessary, redirect their attention to other more appropriate aspects. Moreover, video tape replay and/or the interview can help to facilitate " metacognition" of a performance. Metacognition refers to a learner's "knowledge and cognition about cognition, psychology and monitoring" (Flavell, 1987). Metacognitive knowledge includes person, task and strategies. If learners have the ability to regulate and organize their own performance such as planning, predicting, guessing, monitoring as well as to take advantage of the knowledge already learned and the process involved in learning it (Shuell, 1986), they undoubtedly will be able to speed up the learning process to a productive direction.

This research method which utilizes both the video tape replay and the interview can be employed during the regular instructional session. If the interview for each student takes too much time, alternative means such as "self-checklists" of his/her game performance can be used to regulate and organize their thoughts and performance as contrasted with their technical performance.

One of the examples of such a checklist, the Tennis Game Thought Organization Checklist is presented in Figure 14. After the end of each game in a set, during the practice session, the player completes this

Figure 14. Tennis Game Thought Organization Checklist

Your name _____ Your opponent _____ Date _____ Set score _____

	The games in the set	1	2	3	4	5	6	7	8	9	10	11	12	13
	Game won(o) /lost(x)													
1. Phase of the game	Were you forced?													
	Were you forcing?													
2. Your movement & position	Did you react immediately after you hit the previous shots?													
	Did you move to the best position to hit the best shots ?													
3. Your shot selections	Did you think you choose the best shots in the particular situations?													
	good direction?													
	good depth?													
	good spin?													
	good speed?													
	Did you try to change the pace of the game when you were losing?													
4Psychological aspects	Were you relaxed?													
	Could you concentrate on your shot?													
	Could you anticipate the coming shot: by your shot?													
	by the opponent's cues?													
	Were you offensive?													
	Did you maintain positive attitude when you were forced?													
	Did you have positive self-talk?													
5. Opponent's cues	Were you aware of the opponent's position?													
	Could you identify the opponent's strengths and weaknesses?													
	serves?													
	ground strokes?													
	volleys?													
	overhead?													
	quickness?													
	endurance?													

Category 1 (Phase of the game) will be answered by:

Y=yes, N=no.

Categories 2-5 will be answered by:

O=You tried and you could executed as you want.

Δ=You tried but it was not successful.

X=You did not know what to focus on.

checklist to confirm whether he/she was paying attention to the appropriate situational cues, or maintaining the most beneficial psychological status, and whether he/she made correct decisions in order to perform within his/her optimal ability. If the items in this checklist are too numerous for a player who has just started to play games, the instructor can reduce the number of the items upon which the player should focus. The alternate way of using this checklist is in conjunction with the video tape replay. Just after each game, the player observes his/her own performance on the video monitor and checks his/her tactical thoughts and psychological aspects. This is a unique useful way to guide and expand their attentional focus during the game situation.

6.2. Suggestions for Future Studies.

This study indicated that case study method based on the thought-revealing interviews aided by video tape replay was very profitable for the study of the acquisition of skills in an open skill sport. Moreover, the exploration of novice tennis players' thought processes and knowledge structure development in itself has been valuable in providing guidelines to better instruction, not only for tennis student, but also for all open skill sports.

A continuation of this exploratory research from the novice through the expert level is suggested to further understand the qualitative changes that occur in players' cognitive characteristics as they progress. Such research may be used to guide the design of long term developmental instructional programs leading from the novice to the expert levels (Chi &

Glaser, 1980). Moreover, these studies may be used to integrate the players subjective schema into objective performance criteria. In our tennis situation, development of a players schema could be combined with the National Tennis Rating Program. Not only observable performance, but also the players' knowledge structures relating to the game situations could be integrated into the hierarchical developmental criteria.

The learners' thought processes and knowledge structures mediate between the teacher's presentation of information and the optimal result of the learning (Shuell, 1986; Wittrock, 1986). With a more complete understanding of this process, we will be able to provide a learning environment in which the learners will have active role in their own learning and they will better understand the purposes and reasons for their own action.

REFERENCES

Allard, F., & Burnett, N. (1985). Skill in sport. Canadian Journal of Psychology, 39(2), 294-312.

Anderson, J. R. (1982). Acquisition of cognitive skill. Psychological Review, 89, 369-406.

Anderson, J. R. (1985). Cognitive psychology and its implications. (2nd ed.). New York: W. H. Freeman and Company.

Bard, C., & Fleury, M. (1976). Analysis of visual search activity during sport problem situations. Journal of Human Movement Studies, 3, 214-222.

Bloom, B. S. (1953). Thought processes in lectures and discussions. Journal of General Education, 7, (3), 160-169.

Chase, W. G., & Chi, M. T. H. (1981). Cognitive skill: Implications for spatial skill in large-scale environments. In J. H. Harvey (Ed.), Cognition, social behavior, and the environment (pp. 111-136). New Jersey: Lawrence Erbaum Associate Publishers.

Chase, W. G., & Simon, H. (1973a). Perception in chess. Cognitive Psychology, 4, 55-81.

Chase, W. G., & Simon, H. (1973b). The mind's eye in chess. In W. G. Chase, (Ed.), Visual information processing (pp. 215-281). New York: Academic Press.

Chi, M. T. H. (1987). Representing knowledge and metaknowledge: Implications for interpreting metamemory research In F. E. Weinert & R. H. Kluwe (Eds.), Metacognition, motivation and understanding (pp. 238-265). London: Lawrence Erlbaum Associates Publishers.

Chi, M. T. H., Feltovich, P. J., & Glaser, R. (1981). Categorization and representation of physics problems by experts. Cognitive Science, 5, 121-152.

Chi, M. T. H., Glaser,R., & Farr, M.J. (1988). The nature of expertise. Hillside, NJ: Lawrence Erlbaum Associates Publisher.

Chi, M. T. H., & Glaser, R. (1980). The measurement of expertise: Analysis of the development of knowledge and skill as a basis for assessing achievement. In E. Baker, & E. Quellmalz (Eds.), Educational testing and evaluation: Design, analysis and policy (pp. 37-47). Beverly Hills: Sage Publications.

Clark, C., & Peterson, P. (1981). Stimulated recall. In B. R. Joice, C. C. Brown, & L. Peck (Eds.), Flexibility in teaching: An excursion into the nature of teaching and training (pp. 256-261). New York: Longman Inc..

Clark, C. M., & Peterson P. L. (1986). Teachers' thought processes. In M. C. Wittrock (Ed.), Handbook of research on teaching (3rd ed.) (pp. 255-296). New York: MacMillan Publishing Company.

Dreyfus, H. L., & Dreyfus, S. E. (1986a). Mind over machine: The power of human intuition and expertise in the era of the computer. New York: Free Press.

Dreyfus, H. L., & Dreyfus, S. E. (1986b). Why skill cannot be represented by rules. In N. E. Sharkey (Ed.), Advance in cognitive science (1), (pp. 315-335). Ellis Horwood Limited.

Erickson, F. (1986). Qualitative methods in research on teaching. In M. C. Wittrock (Ed.), Handbook of research on teaching (3rd ed.) (pp.119-161). New York: MacMillan Publishing Company.

Ericsson, K. A., & Simon, H. A. (1980). Verbal reports as data. Psychological Review, 87, (3), 215-251.

Ericsson, K. A., & Simon, H. A. (1984). Protocol analysis: Verbal reports as data. Massachusetts: The MIT Press.

Fitts, P. M. (1964). Perceptual-motor skill learning. In A. W. Melton (Ed.), Categories of human learning (pp. 243-285). New York: Academic Press.

Flavell, J. H. (1987). Speculations about the nature and development of metacognition. In F. E. Weinert, & R. H. Kluwe (Eds.), Metacognition, motivation and understanding (pp. 21-29). London: Lawrence Erlbaum Associates Publishers.

Fumoto, N. (1989). Conformation of learning efficiency in physical movement. Journal of Health, Physical Education and Recreation, August, 39, (8) 598-605. (a Japanese Journal).

Gardner, M. K. (1985). Cognitive psychological approaches to instructional task analysis. In E. W. Gordon (Ed.), Review of research in education, (12). (pp. 157-195) Washington D. C.: American Educational Research Association.

Gentile, A. M. (1972). A working model of skill acquisition with application to teaching. Quest, 17, 3-23.

Glaser, B. G., & Strauss, A. L. (1967). The discovery of grounded theory. Chicago: Aldine Publishing Company.

Glencross, D. J. (1978). Cognitive Structure and the Acquisition of skill. In D. J. Glencross (Ed.), Psychology and Sport (pp. 97-119). Sydney: McGraw-Hill Book Company.

Goetz, J. P. & LeCompte, M. D. (1984). Ethnography and qualitative design in educational research. San Diego: Academic Press.

Goldenson, R. M. (1984). Longman dictionary of psychology and psychiatry. New York: Longman Inc.

Griffin, P. S. (1984). Girls' participation patterns in a middle school team sports unit. Journal of Teaching in Physical Education, 4, 30-38.

Grimmett, P. P. (1982). The Clinical supervision conference: An exploratory study. Unpublished doctoral dissertation, University of British Columbia, Vancouver.

Housner, L.D. (1981). Skill in badminton. Unpublished paper presented at NASPHA meeting, California.

Housner, L. D., & Griffey, D. C. (1985). Teacher cognition: Differences in planning and interactive decision making between experienced and inexperienced teachers. Research Quarterly for Exercise and Sport, 56, (1), 45-53.

Jewett, A. E. (1981). Purpose process curriculum framework. In W. Harringston (Ed.), Proceeding of the second conference on curriculum theory in physical education (pp. 126-146). University of Georgia.

Jewett, A. E. & Mullan, M. R. (1977). Curriculum design: Purposes and processes in physical education teaching learning. American Alliance for Health, Physical Education and Recreation and Dance. Washington D. C..

Kanamoto, M. et al (1979). A research on fixation of goal keeper. Journal of Physical Education in Toritsu University, 2 103-110. Tokyo: Toritsu University. (a Japanese Journal).

Kirschenbaum, D. S., & Wittrock, D. A. (1984). Cognitive- behavioral interventions in sport: A self-regulatory perspective. In J. M. Silva, & R. S. Weinberg (Eds.), Psychological foundations of sport (pp. 81-99). Champaign, IL: Human Kinetics Publishers.

Kyllonen, P. C., & Christal, R. E. (1989). Cognitive modeling of learning abilities: A status report of LAMP. In R. F Dillon, & J. W. Pellegrino (Eds.), Testing: Theoretical and applied perspectives New York: Praeger.

Leinhardt, G., & Smith, D. (1986). Expertise in mathematics instruction: Subjective matter knowledge. Journal of Educational Psychology 77, (3), 247-271.

Locke, L. F., Spirduso, W. W. & Silverman, S. J. (1987). Proposals that Work (2nd ed.). Newbury Park, CA: Sage Publications.

Lohman, D. F. (1989). Human intelligence: An introduction to advances in theory and research. Review of Educational Research, 59, (4), 333-373.

Magill, R. A. (1989). Motor learning: Concepts and applications (3rd ed.). Dubuque, IA: Wm. C. Brown Publisher.

Miles, M. B., & Huberman, A. M. (1984). Qualitative data analysis. Beverly Hills: Saga Publications.

McMillan, J. H., & Schumacher, S. (1989). Research in education: A conceptual introduction. Glenview, IL: Scott Foresmar.

Neisser, U. (1976). Cognition and reality. San Francisco: W. H. Freeman and Company.

Neves, D. M., & Anderson, J. R. (1981). Knowledge compilation: Mechanisms for the automatization of cognitive skills. In J. R. Anderson (Ed.), Cognitive skills and their acquisition (pp. 57-84). Hillsdale, NJ: Erlbaum Associates.

Newell, A., & Simon, H. A. (1972). Human problem solving. Englewood Cliffs, NJ: Prentice-Hall.

Newell, K. M., & Barclay, C. R. (1982). Developing knowledge about action In J. A. S. Kelso & J. E. Clark (Eds.), The development of movement control and co-ordination (pp. 175-212). Toronto: John Wiley & Sons.

Nisbett, E. R., & Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental process. Psychological Review, 84, (3), 231-259.

Oguchi-Chen, F. (1986). Evaluation process for the enhancement of motor skill acquisition and its application. Unpublished manuscript.

Peterson, P. L., Swing, S. R., Braverman, M. T., and Buss, R. (1982). Students' aptitudes and their reports of cognitive process during direct instruction. Journal of Educational Psychology, 74, (4), 535-547.

Ponser, M. I. (1988). Introduction: What is it to be an expert? In M. T. H. Chi, R. Glaser, & M. J. Far. (Eds.), The nature of expertise (pp. xxix-xxxvi) Hillside, N J: Lawrence Erlbaum Associates.

Reber, A. S. (1985). The Penguin Dictionary of Psychology. New York: Viking.

Reitman, J. S. & Rueter, H. H. (1980). Organization revealed by recall orders and confirmed by pauses. Cognitive Psychology, 12, 554-581.

Schmidt, R. A. (1988). Motor control and learning: A behavioral emphasis. Champaign, IL: Human Kinetics.

Shavelson, R. J., Webb, N. M. & Burstein, L. (1986). Measurement of teaching. In M. C. Wittrock, (Ed.), Handbook of Research on Teaching (3rd ed.) (pp. 50-91) New York: MacMillan Publishing Company.

Shavelson, R.J. & Stern, P. (1981). Research on teachers' pedagogical thought, judgment, decisions, and behavior. Review of Educational Research, 51, (4), 455-498.

Shuell, T. (1986). Cognitive conception of learning. Review of Educational Research, 56, (4), 411-436.

Sinclair, G. (1983). Intentional rather than incidental learning (Designing the Learning Environment). In A. Jewett, M. Carrnes, & M. Speakman (Eds.), Proceeding of the third conference on curriculum theory in physical eduction. University of Georgia.

Singer, R. N. (1982). The learning of motor skills. New York: Macmillan.

Sutherland, S. (1989). The international dictionary of psychology. New York: Continuum.

Tennyson, R. D. & Rasch, M. (1988). Linking cognitive learning theory to instructional prescription. Instructional Science, 17, 368-385.

Tuckwell, N. B. (1980). Stimulated recall: Theoretical perspectives and practical and technical considerations. (Tech. Rep. No. 80-2-3) Edmonton, Canada: University of Alberta, Center for Research in Teaching.

United State Professional Tennis Association (1984). Tennis: A professional guide New York: Kodansha International.

Vickers, J. N. (1986). The resequencing task: Determining expert-novice differences in the organization of a movement sequence. Research Quarterly for Exercise and Sport, 57, (3), 260-264.

Vickers, J. N. (1988). Knowledge structures of expert-novice gymnasts. Human Movement Science, 7, 47-72. North-Holland.

Vickers, J. N. (1990). Instructional design for teaching physical education. Champaign IL: Human Kinetics.

Weinstein, C. E. & Mayer, R. E. (1986). The teaching of learning strategies. In M. C. Wittrock (Ed.), Handbook of research on teaching (3rd ed.) (pp. 315-327) New York: MacMillan Publishing.

Whiting, H. T. A. (1982). Skill in sport --A descriptive and prescriptive appraisal In J. H. Salmela, J. T. Partington, & T. Orlick (Eds.), New paths to sport learning and excellence. Sport in Perspective Inc. and the Coaching Association of Canada.

Wittrock, M. C. (1986). Students' thought processes In M. C. Wittrock (Ed.), Handbook of Research on Teaching (3rd ed.) (pp. 297-314) New York: MacMillan Publishing.

Yin, R. K. (1989). Case study research: Design and methods. Newbury Park, CA: Sage Publications.

Appendix 1

National Tennis Rating Program (NTRP) Rating Categories

NTRP Rating Categories

1.0 This player is just starting to play tennis.

1.5 This player has limited playing experience and is still working primarily on getting the ball over the net; has some knowledge of scoring, but is not familiar with basic positions and procedures for singles and doubles play.

2.0 This player may have had some lessons but needs on-court experience; has obvious stroke weaknesses but is beginning to feel comfortable with singles and doubles play.

2.5 This player has more dependable strokes and is learning to judge where the ball is going; has weak court coverage, or is often caught out of position, but is starting to keep the ball in play with other players of the same ability.

3.0 This player can place shots with moderate success; can sustain a rally of slow pace, but is not comfortable with all strokes; lacks control when trying for power.

3.5 This player has achieved stroke dependability and direction on shots within reach, including forehand and backhand volleys, but still lacks depth and variety; seldom double-faults and occasionally forces errors on the serve.

4.0 This player has dependable strokes on both forehand and backhand strokes; has the ability to use a variety of shots including lobs, overheads, approach shots, and volleys; can place the first serve and force some errors; is seldom out of position in a doubles game.

4.5 This player has begun to master the use of power and spins; has sound footwork; can control depth of shots and is able to move opponent up and back; can hit first serves with power and accuracy, and place the second serve; is able to rush net with some success on serve in singles as well as doubles.

5.0 This player has good shot anticipation; frequently has an outstanding shot or exceptional consistency around which a game may be structured; can regularly hit winners or force errors off of short balls; can successfully execute lobs, dropshots, half-volleys, and overhead smashes; has good depth and spin on most second serves.

5.5 This player can execute all strokes offensively and defensively; can hit dependable shots under pressure; is able to analyze opponents' styles, and can employ patterns of play to assure the greatest possibility of winning points; can hit winners or force errors with both first and second serves, return of serves can be an offensive weapon.

6.0 This player has mastered all the above skills; has developed power and/or consistency as a major weapon; can vary strategies and styles of play in a competitive situation; typically has had intensive training for national competition at junior or collegiate levels.

6.5 This player has mastered all of the preceding skills and is an experienced tournament competitor who regularly travels for competition, and whose income may be partially derived from prize winnings.

7.0 This is a world-class player.

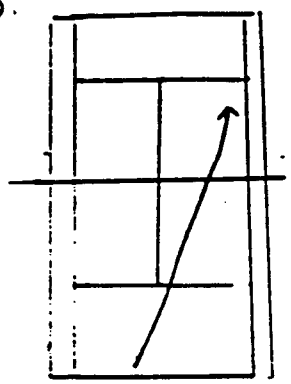
Although it is possible to be rated in increments of .1, most organized tournaments, leagues, and ladders are set up on increments of .5. A player rated 2.7, for example, would be required to play in the 3.0 category in a league situation.

Some may prefer to be rated by a pro or an objective observer familiar with the system. Since

From Tennis - A professional guide (USPTA, 1984), p 104.

A/3. SV R.M.

10.



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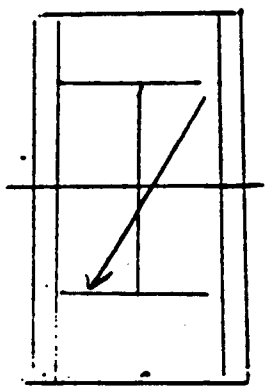

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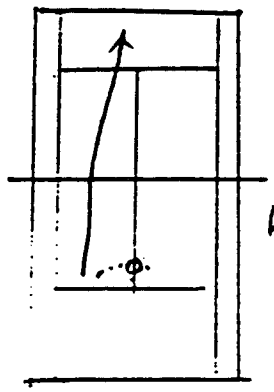

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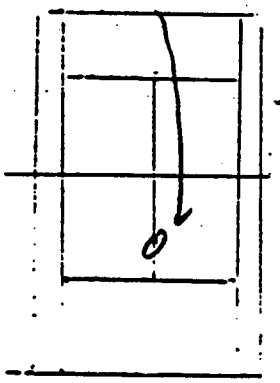

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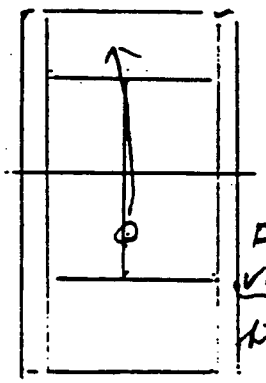

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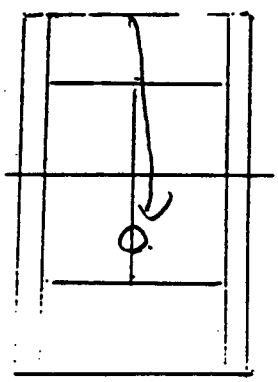

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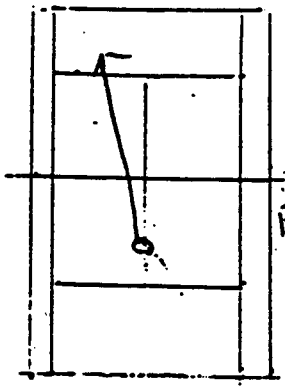

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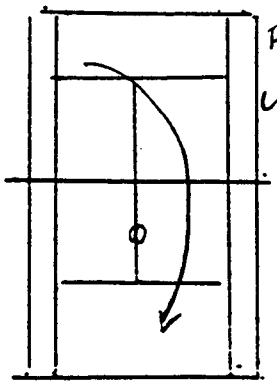

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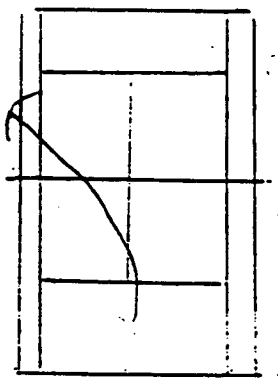

OH wide (-F)

Appendix 4. Thought and Performance Development Questionnaires

1. Do you think the interview make you think or think more about your tennis games?

very much 1 2 3 4 5 not at all

comments:

2. Do you think the video cassette replay facilitates your thinking about your tennis game

very much 1 2 3 4 5 not at all

comments:

3. Do you think the joint use of video cassette replay and the interview make you think more about your tennis games than using either alone?

very much 1 2 3 4 5 not at all

comments:

4. Comparing the video replay and the interview (each used by itself), which of the two seems more effective to make you think about your game?

which? video replay or interview

why?

5. Do you think your thought process has become more structured or organized as a result of having the interview?

very much 1 2 3 4 5 not at all

comments:

6. Do you think that continued use of video replay and the interview week after week <u>continuously</u> serves the purpose of making you think (or think more) about the game during the game?

very much 1 2 3 4 5 not at all

comments:

7. As you are improving your skill in playing tennis during these four weeks, do you think that more thoughts are coming across in your mind as you are playing the games?

very much 1 2 3 4 5 not at all

comments:

8. In relation to question 7, if your answer is in the affirmative end of the scale, do you attribute your increased thinking to your contact with the video replay and the interview, <u>or</u> do you feel that your thinking process has been improving as you have become a better player?

comments: