KNOWLEDGE BASE AND CHILDREN'S LONG-TERM RETENTION

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by

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ABSTRACT

Much of the knowledge base research has provided evidence to show that children's memory performance is facilitated when they have a well integrated and large body of knowledge. Unfortunately, much of this research has focused on acquisition, but not long-term retention processes, although both of these processes are important in everyday cognition. In this dissertation, I investigated if the facilitory effects of changes in children's knowledge (specifically, structural changes) on acquisition processes also occur for long-term retention processes.

The purpose of the first experiment was to determine the nature of the structure of knowledge for children of different ages and levels of expertise. This study provided stimulus materials to investigate the relationship between changes in knowledge structure and memory processes in the second experiment. In the first experiment, 213 children (ages 6 to 14) with soccer expertise (Experiment IA) and 29 children (ages 7 to 13) with tennis expertise (Experiment IB) generated a story in their area of expertise. The results showed that there are age- and expertise-related changes in the structure of knowledge.

In Experiment II, 93 subjects (44 8-year olds, 49 11-year olds) with either low or high expertise in soccer memorized one of two domain-related stories, then after a 4-

week retention interval, recalled the story. One story reflected the knowledge structure of low experts (poor storytype), the other reflected the knowledge structure of high experts (good storytype). The results of this study showed that at acquisition, children had better recall for the story consistent with their current level of knowledge elaboration. More importantly, at long-term retention, performance was better for children with well elaborated knowledge (high in expertise), compared to children with less elaborated knowledge (low in expertise).

Taken together, this dissertation research indicated that first, developmental differences in the structure of knowledge are not minimized for experts in a particular domain. Second, this research suggested that the influence of knowledge on memory performance is different for acquisition and long-term retention processes. The influence of knowledge on memory performance was greater for the initial acquisition than the long-term retention of information. Further, for long-term retention, the effects of knowledge varied depending on whether performance decrements (forgetting) or increments (hypermnesia) were measured. The findings were discussed with respect to the nature of the relationship between knowledge factors and both memory acquisition and long-term retention processes.

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CHAPTER I

KNOWLEDGE BASE AND CHILDREN'S LONG-TERM RETENTION

An important factor in understanding the development of children's memory is the presence of an elaborated knowledge base. Substantial evidence exists to show that children's memory performance is facilitated when they have a well integrated and large body of knowledge. To date, much of the research on this topic has focused on the acquisition of information. This is a curious trend since everyday memory consists of acquiring information and then retrieving that information after some length of time. This disregard of the long-term retention of information seems particularly bewildering given the evidence that acquisition and retention processes are influenced by different factors (e.g., Howe & Brainerd, 1989).

There have been very few investigations of the role of knowledge on the retrieval of information over extended periods of time. This lack of attention to children's long-term retention has likely occurred because researchers failed to find significant age differences in retention. However, this was largely because of methodological and design flaws in this early research. More recent evidence suggests that long-term retention is an important part of the memorization process, and that acquisition and long-term retention obey different laws for children (e.g., Brainerd, Kingma, & Howe, 1985; Howe & Brainerd, 1989; Howe & Hunter, 1986). Discovering the processes responsible for both the acquisition and long-term retention of memory traces is necessary to advance memory development research (e.g., Howe, Kelland, Bryant-Brown, & Clark, 1992). Specifically, it is important to determine if the facilitory effects of changes in children's knowledge base on memory acquisition also occur for long-term retention. This information would be important for curriculum development and classroom learning, for example.

In this chapter, I present an overview of the knowledge base and long-term retention literatures. These reviews include a discussion of the methodological problems inherent in much of this research, as well as solutions to these difficulties. Finally, I propose hypotheses regarding the relationship between knowledge and long-term retention, and outline the three research studies of this investigation. The purpose of the first two studies was to determine the structure of knowledge and to generate stimulus materials for the third study. The purpose of the third study was to investigate the effects of differences in the knowledge base on the development of both memory acquisition and long-term retention processes. To study the effects of differences in children's knowledge on memory processes (Experiment II), it is important to know what knowledge exists and how that knowledge is structured (Experiments IA and IB). Thus, the focus of this dissertation was on the relationship between differences in the structure of knowledge and memory processes, specifically long-term retention.

A. Knowledge Base Literature

Developmental trends in memory have been attributed to an increase in the ability to use mnemonic strategies (e.g., Bjorklund, 1989; Moely, 1977; Ornstein & Corsale, 1979; Ornstein & Naus, 1985). Strategies typically refer to deliberate plans subject to conscious evaluation, and utilized to enhance performance (e.g., Bjorklund, 1989; Brown, 1975; Howe & O'Sullivan, 1990; Naus & Ornstein, 1983; Pressley, Forest-Pressley, Elliot-Faust, & Miller, 1985). Although older children use strategies more effectively than younger children, this does not account for all the developmental differences in memory performance. For example, age differences in memory functioning often remain after differences in strategic processing have been minimized (e.g., Chi & Ceci, 1987). Furthermore, there is evidence that differences in semantic knowledge (primarily knowledge of taxonomic categories) contribute to developmental differences in memory performance (e.g., Bjorklund, 1985, 1987, 1989; Chi, 1985). That is, performance differences were minimized, but were not entirely eliminated, when stimulus materials were equally familiar to all children (Bjorklund, 1987). This section begins with a discussion of definitional issues around the term knowledge, and is followed by a review of the research directed toward the influence of knowledge on memory performance.

Definitional Issues

There have been difficulties in operationally defining knowledge base, which refers to what children know, with various researchers using different definitions. For example, Bjorklund (1987) emphasizes the semantic memory components of the knowledge base and his research has focused on the development of knowledge of the meaning of, and relations between, words and concepts. In contrast, Chi (1985) defines knowledge base as declarative knowledge, which includes semantic knowledge and general-world and domain-specific knowledge. These differences in definitions reflect the general agreement today that there are several types of knowledge included in the knowledge base (e.g., Chi & Ceci, 1987).

Measurement issues have also plagued this research. Specifically, how should one measure how much knowledge exists so that one also adequately captures the nature of how that knowledge is structured? Such a measurement is important because today it is generally assumed that both the contents and structure of knowledge change with development (e.g., Chi & Ceci, 1987; Howe & O'Sullivan, 1990; Schneider, Korkel, & Weinert, 1990). Content knowledge refers to how much and what knowledge an individual has in a particular domain. Structure refers to the configuration or arrangement of knowledge, including the pattern of interrelations among information (e.g., Chi & Koeske, 1983; Gobbo & Chi, 1986). Further, performance on cognitive tasks is related not only to the presence or absence of knowledge, but also how that knowledge is structured (Chi & Ceci, 1987; Chi & Koeske, 1983; Gobbo & Chi, 1986). Given this, researchers should study the contents of the knowledge base as well as the changes in the structure of that knowledge. Although there has been a difficulty in finding adequate means of measuring structure, advances have recently been made in the availability of sophisticated measurement procedures (e.g., Chi & Ceci, 1987; Howe & O'Sullivan, 1990).

However, content knowledge determines in part, the structure of knowledge, which highlights the theoretical difficulty surrounding this issue. Some investigators suggest that these two factors should be unconfounded if possible (e.g., Chi & Ceci, 1987, Chi, Hutchinson, & Robin, 1989). Chi and Ceci have argued that having more knowledge in a domain might imply a more elaborated, integrated structure, and they speculated that changes in structure most likely represent increases in the amount of existing knowledge and some type of reorganization of the existing knowledge. Alternatively, it is possible to discuss structure without discussing content. For example, Chi and Ceci (1987) have argued that two children could have the same amount of knowledge, but the knowledge for one child could be in a better structure, which may manifest as differences in cognitive performance between the two children.

For this dissertation, I chose to focus on domain-specific knowledge, defined as knowledge about either the sport of soccer or tennis. Recognizing the content and structure issue as a difficulty in the field, I proceeded by looking at both the interplay and separation of content knowledge and its structure. Content knowledge was measured as the specific type of information (e.g., the topics) generated when children were asked to tell a story in a particular domain. Structure was investigated by measuring the quality of the stories generated in terms of the inclusion of appropriate parts of a story as well as the connections among these parts. In this dissertation the term structure is used interchangeably with representation. To study the relationship between knowledge and cognitive processing I investigated how memorizing information (content knowledge) of different structure (e.g., poor versus good) influences memory processing.

There are a number of techniques that have been used to uncover the structure of knowledge, such as multidimensional scaling, node-link schema, categories, and scripts (e.g., Chi & Ceci, 1987; Falmagne & Doignon, 1988), which are used for different types of knowledge (e.g., conceptual knowledge, events). Unfortunately, there are problems with all these approaches. For example, with multidimensional scaling there are problems determining the correct metric and in Markov modelling the knowledge domain is typically known in advance. Consistent with Chi and Ceci's (1987) claim that the types of measures used depend on the researchers needs, I chose to use story grammars because the focus of this research was on the representation of story knowledge (as opposed to concepts, for example). In addition, story representation, while more difficult to quantify, enables researchers to learn more about knowledge organization (Chi & Ceci, 1987) because it more adquately captures the complexities of knowledge.

Research Findings

Evidence that changes in knowledge are responsible for some of the improvements in memory performance comes from research involving children's understanding of taxonomic information (e.g., Bjorklund, 1985, 1987; Bjorklund &

Thompson, 1983; Bjorklund, Thompson, & Ornstein, 1983; Duncan & Kellas, 1978; Mervis & Rosch, 1981; Ornstein & Corsale, 1979; Rabinowitz, 1984; Rosch, 1973; Rosch & Mervis, 1975) and domain-specific knowledge (e.g., Bjorklund & Zeman, 1982, 1983; Chi, 1978, 1985; Chi & Koeske, 1983). More recently, further support has been gained for the relationship between knowledge and memory performance with experts and novices in a particular domain (e.g., Gaultney, Bjorklund, & Schneider, 1992; Korkel & Schneider, 1989; Schneider, Korkel, & Weinert, 1989, 1990). These research findings are elaborated below.

First, the results of category typicality research have clearly established that there are differences in the representativeness of category items. Both children and adults are better at deciding if an item is a member of a particular category when the item is highly typical of that category than when it is not (e.g., ROBIN is a highly typical member of the BIRD category whereas OSTRICH is a less typical member). Further, children's and adult's conceptions of category members differ (e.g., Bjorklund, 1985; Bjorklund & Thompson, 1983; Bjorklund et al., 1983; Clark, 1989; Duncan & Kellas, 1978; Rabinowitz, 1984). Children first obtain knowledge of the most prototypical or representative categorical items, and as they get older the boundaries of their categories expand (e.g., Bjorklund et al., 1983; Rabinowitz, 1984; Mervis & Rosch, 1981; Rosch, 1973; Rosch & Mervis, 1975). For example, Clark (1989) showed that children of different ages do not rate words in the same way. Employing the three semantic categories of animals, birds, and parts-of-the-body, she found that there were age differences in children's ratings of high and low typical instances of each category. For example, grade two subjects had more words rated as high and low typical that were unique for that grade, compared to grade six and ten subjects. With increasing grade, there was more overlap of words rated as high and low typical category members.

Age differences in category knowledge are reflected in memory performance. First, memory performance was better overall for children who remembered items based on child ratings of category typicality compared to adult generated word lists (e.g., Bjorklund, 1985, 1987; Bjorklund & Thompson, 1983; Bjorklund et al., 1983; Clark, 1989; Ornstein & Corsale, 1979). Second, recall was better and more organized for highly typical compared to less typical category items for both child-generated and adult-generated lists. Recall of less typical, but not typical words, was better when subjects remembered items based on child-generated word lists. Because judgements of category typicality first become more consistent with age for typical items, differences in memory should be greatest with less typical items. This is because many less typical items for adults have not yet been judged to be category members by children (e.g., Bjorklund, 1985, 1988; Bjorklund, Bernholtz, & Schwartz, 1985; Bjorklund & Buchanan, 1989, Clark, 1989). This research suggests that children's memory performance was facilitated when tested with materials consistent with their current level of knowledge base development (e.g., current conception of category items).

Second, differences in domain-specific knowledge play a role in children's memory performance. For example, Bjorklund and Zeman (1982, 1983) reported that children's level of recall and organization improved for classmate names and was higher than that generally found on a standard taxonomic list. They asked first-, third-, and fifth-grade children to recall both a list of categorized words and names of children currently in their class. On the first test older children outperformed younger children, a finding not unexpected because there are age differences in knowledge of the category words. However, when children were asked to recall classmates' names, age differences in knowledge were minimized. This occurred ostensibly because all children, regardless of age, are equally familiar with their classmates. Chi and Koeske (1983) reported high levels of memory organization at output of dinosaur names for a child considered an expert in his knowledge of dinosaurs. Further, Chi (1978) discovered that expert chess players (in this case children) showed better memory performance than novice chess players (in this case adults). Typical developmental trends occurred with a traditional digit-span task.

Third, and perhaps the most impressive demonstration of how prior knowledge facilitates memory performance, are studies contrasting experts and novices in a particular domain (e.g., Chi, 1978; Gaultney et al., 1992; Knopf, Korkel, Schneider, & Weinert, 1988; Korkel & Schneider, 1989; Schneider & Korkel, 1989; Schneider et al., 1989, 1990). For example, Korkel and Schneider (1989) and Schneider et al. (1989) used the expert-novice paradigm to investigate the influence of soccer knowledge on memory performance for third-, fifth-, and seventh-grade children. Based on a questionnaire that assessed knowledge of soccer rules and events, half the subjects at each age level were classified as experts and half as novices. For both studies (Korkel & Schneider, 1989; Schneider et al., 1989), experts recalled a story about a soccer game better than novices, regardless of age. These studies provided further evidence that children's prior knowledge is an important factor in memory performance.

Last, the explanation for better memory performance comes from an understanding of how knowledge changes with age or expertise. Chi and Koeske (1983) and Gobbo and Chi (1986) have directly studied structural changes in knowledge. Chi and Koeske used a production task where a child knowledgable about dinosaurs was asked to list names of dinosaurs and the properties associated with them. The sequencing and repetition of information generated during this task was taken as evidence for the structure of information in semantic memory. For example, two names generated in succession were assumed to be linked in semantic memory, and properties mentioned for several dinosaurs were assumed to provide an indication of the pattern of interrelatedness in semantic memory (i.e., the structure). They reported that differences between better and lesser known dinosaur knowledge was due to differences in structure. Further, Chi and Koeske suggested that memory performance improved for better known knowledge because it matched the structure of information in the knowledge base for the child expert in this area. Gobbo and Chi (1986) also investigated the structure and use of knowledge in expert and novice children. In their study, knowledge structure was assessed by evaluating the frequency of connecting words (e.g., "because" and "if"), and the switching of topics evident when children were shown a picture of a dinosaur and asked to tell everything they know about that dinosaur. They reported that compared to novices, expert children's knowledge was more structured as indicated by production protocols that were better connected and more like coherent discourse. Further, the experts could access and use their knowledge better as seen in making more inferences and semantic comparisons.

As children become more knowledgeable in an area, there are corresponding increases in the cohesiveness or integratedness of the information. Such knowledge forms structured, integrated conceptual schemes, which results in more meaningful and familiar knowledge (e.g., Chi & Koeske, 1983; Gobbo & Chi, 1986; Rabinowitz, 1984). In other words, an elaborated knowledge base includes more items, that are represented with more features, with stronger inter- and intra-item relations, and stories that are more complete (e.g., Bjorklund, 1987; Chi, 1978, Chi & Ceci, 1987). Elaborated items are thought to be accessed from memory with less effort, leaving information processing capacity for other operations, such as strategy use (e.g., Bjorklund, 1987, 1989). Information in a detailed knowledge base can also facilitate memory performance by enhancing retrievability of individual items (e.g., Bjorklund, 1987 for a review). Thus, children with more expertise in an area should be able to use their well represented knowledge in order to enhance memory performance, compared to children with less expertise (e.g., Gobbo & Chi, 1986).

To summarize, research supports the idea that knowledge is an integral aspect of memory development (e.g., Bjorklund, 1985; Chi & Ceci, 1987; Ornstein & Naus, 1985; Schneider et al., 1990). When tested with familiar materials, children's memory performance is comparable to adults, "because what is considered familiar to adults may not be familiar to children" (e.g., Chi & Koeske, 1983 p. 37). Specifically, typical age differences in memory recall can be minimized when children memorize information they are more familiar with or that is better represented in their knowledge base. This effect has been shown for both semantic memory concepts, and domain-specific knowledge. The effects of well integrated knowledge on memory performance occur presumably because such information is more easily retrieved. Unfortunately, much of this research has centred on studying how changes in the knowledge base facilitate the initial acquisition of information. Researchers are just beginning to investigate if the advantages of memorizing elaborated knowledge enhance the long-term retention of information (e.g., Chi & Koeske, 1983; Clark & Howe, 1990; Yussen, Stright, Glysch, Bonk, Lu, & Al-Sabaty, 1991). An essential question then, given the evidence for the importance of knowledge to the acquisition of information, is whether knowledge is similarly beneficial to long-term retention. The long-term retention literature is reviewed next and is followed by a discussion of the relationship between these two factors.

B. Long-Term Retention Literature

This section begins with a discussion of definitional issues, that is followed by a review and critique of the long-term retention literature. Briefly, greater precision of definitions has been paralleled by a renewed interest in studying developmental changes in long-term retention. Long-term retention is now thought to consist of two components, performance decrements and increments, which correspond to forgetting and hypermnesia. The early forgetting research generally indicated no developmental trends in forgetting. However, these conclusions must be tempered by evidence that much of this early work was methodologically and procedurally unsound. More recent research that overcomes these problems shows that there are developmental differences in forgetting. The hypermnesia research was plagued with some of the same methodological problems inherent in the forgetting area. Unlike the recent forgetting research, the studies of hypermnesia have not so clearly identified developmental trends, even for more recent methodologically sound investigations.

Definition of Terms

Precise definitions of long-term retention have recently been provided in the literature (e.g., Howe & Brainerd, 1989). Long-term retention performance depends on the relationship between both performance decrements and increments over time. It has become apparent that investigations of developmental trends in long-term retention must adequately separate factors that depress performance from factors that enhance performance. This precision in definitions has allowed investigators to study more clearly the relationships between initial learning and later recall and the changes in items recalled over a series of retention tests. Specifically, long-term retention can be evaluated by comparing performance at the acquisition session with performance at the retention session, and/or by comparing the number of items remembered on the first retention test with the number remembered on successive test trials, as occurs in multiple trial retention studies.

For this dissertation, long-term retention was defined as including the global performance measures of forgetting and hypermnesia, consistent with current usages of the term (e.g., Brainerd et al., 1985; Howe et al., 1992). Forgetting refers to net performance decrements, which occurs when fewer items are recalled at retention than at the end of acquisition, or on later compared to earlier retention tests. Hypermnesia refers to net performance increases, which occurs when more items are recalled on later compared to earlier retention tests. Because a stringent acquisition criterion design (e.g., perfect recall at the end of the learning session) was used in this dissertation, the only change in performance that could be observed between initial learning and later retention was forgetting. In other words, because recall is at criterion after acquisition, there is no room for improvement across the retention interval (see Howe & Brainerd, 1989). An additional situation where forgetting, and in this case hypermnesia, can occur is during the retention test itself. Specifically, with multiple trial designs, recall levels may vary across the retention phase.

Forgetting

Early research on children's forgetting has yielded few developmental findings of interest (see Howe & Brainerd, 1989, for a review). No age differences in forgetting were reported for both word and picture recognition tasks for a variety of ages and retention intervals (Fajnsztejn-Pollack, 1973; Hasher & Thomas, 1973; Kagan, Klein, Haith, & Morrison, 1973; Lehman, Mikesell, & Doherty, 1974; Morrison, Haith, & Kagan, 1980; Nelson, 1971; Rogoff, Newcombe, & Kagan, 1974; Sophian & Perlmutter, 1980; Wagner, 1978; Wicklegren, 1975). For example, Rogoff et al. (1974) studied forgetting over a few minutes, 1 day, or 7 days using a forced-choice recognition memory for pictures task with 4, 6, and 8 year old children. They found that forgetting increased over the retention interval for all age groups, but found no developmental differences among the groups. Fajnsztejn-Pollack (1973) also investigated picture recognition memory in 5 to 16 year old children across a 2- to 48-week retention interval where subjects received a variable number of learning trials. Consistent with the other authors, Fajnsztejn-Pollack found forgetting over the retention interval for all age groups, but no age differences in retention. She concluded that the performance decrements seen over a variety of retention intervals are independent of age. Similarly, Hasher and Thomas (1973) reported no Age X Retention interaction for picture recognition memory after a 1-week retention interval in 3 to 9 year olds. This early research indicated that with picture recognition tasks and for subjects ranging in age from early childhood to late adolescence, general performance decrements over the retention interval occurred, but without an Age X Retention interaction.

A serious concern with this early research is the exclusive use of recognition versus recall tests. A basic methodological issue in developmental research is to ensure that measurement procedures are maximally sensitive to age changes (e.g., Brainerd, Reyna, Howe, & Kingma, 1990). In general, recognition tasks are less sensitive measures of developmental changes in memory than recall tasks. This use of recognition tests is particularly questionable for studying developmental changes in children's memory because the chances of finding developmental differences in forgetting are decreased. In developmental research, the use of a more sensitive measure such as recall is methodologically more appropriate (e.g., Brainerd et al., 1990; Howe & Brainerd, 1989; Ornstein & Corsale, 1979).

In contrast to the absence of developmental differences in forgetting with recognition tests, counterintuitive findings were found with recall tests, such as less forgetting for younger than older children (e.g., Dempster, 1984; Mishima & Inoue, 1966; Stroud & Maul, 1933; Walen, 1970). For example, Walen (1970) had grade 5 and college students learn high and medium frequency words to a criterion of 80% correct using either a free recall or a backward serial recall procedure. Retention tests occurred immediately (30-seconds) or after a 7-day delay period. Walen found no age differences on the immediate test, however, the children outperformed the college students for serial recall on the delayed test. Similarly, Dempster (1984) had grade 3 and 10 students learn a list of 21 words for either 1 or 3 study-test cycles. Subjects received immediate (2-minute) and delayed (1-day) written retention tests, and a visual recognition test following the delayed test. Dempster found that delayed retention was better for subjects receiving 3 study-test cycles than those receiving 1 cycle, and that there were no age differences in immediate recall and delayed recognition tests. However, there were age differences in retention in a counterintuitive direction. Specifically, younger children showed better performance than older children on delayed recall.

Difficulty interpreting these studies occurs because of a serious methodological flaw, namely, a confound between the degree of initial learning and retention performance (e.g., Brainerd et al., 1985; Howe, 1987; Howe & Brainerd, 1989; Howe & Hunter, 1986; Underwood, 1964). It is well known in the developmental forgetting literature that this problem is of special concern because children of different ages generally vary in learning ability. In developmental studies it is impossible to interpret developmental trends in retention when the initial level of learning has not been equated across different age groups (e.g., Howe & Brainerd, 1989). Any observed differences are open to at least two interpretations, which are elaborated below.

To illustrate, consider developmental studies in which older children learn almost anything faster than younger children. In a typical memory study in which one or at most a few learning trials are given, more of the list items will have been learned for older than younger children. On a subsequent retention test older children will likely show better retention than younger children, but this may be because the former have learned more of the items (i.e., one cannot forget what one has not learned initially). This is the first interpretation of observed developmental trends in retention performance when there are discrepancies in initial levels of learning. That is, any developmental trends in forgetting may be due to age-related differences in initial level of learning, and not to true developmental differences in forgetting (e.g., Brainerd et al., 1985; Howe & Brainerd, 1989; Howe & Hunter, 1986). The second interpretation is that any observed differences may be due to age-related differences in retention processes. It is impossible to determine the true state of an Age X Retention interaction when initial levels of learning are not adequately controlled. In addition, differences in initial levels of learning will be greater as the number of learning trials decrease because learning curves are negatively accelerated (e.g., Brainerd et al., 1990; Brainerd & Howe, 1982).

It is difficult to interpret Walen (1970) and Dempster's (1984) counterintuitive findings because they did not control learning with a stringent acquisition criterion. Their results may be attributable to a confound between levels of learning and age, which can be explained as follows. Retention may reflect variations in retrievability of items at the end of acquisition, rather than declines in performance (e.g., Brainerd et al., 1990). Because easier items are acquired more rapidly than harder items, and older children learn faster than younger children, they will have learned more of the list items at the end of acquisition. At retention, younger children may appear to have better retention because they can retrieve easier items learned previously. Older children's retention may appear to be poorer because they have learned more and harder items, that may be more difficult to retrieve (e.g., Brainerd et al., 1990). In other words, "the fact that older children reach more advanced learning stages means that they acquire information that is intrinsically easier to lose" (Brainerd et al., 1990, p. 10). Thus, younger children may appear to have better retention than older children.

Age-related changes in retention performance have been found in research where the levels-of-learning confound has been overcome. This is accomplished through the use of a stringent acquisition criterion that requires all children have learned material completely at the end of a series of learning trials (e.g., Brainerd et al., 1985; Howe, 1987; Howe et al., 1992). For example, Brainerd et al. (1985) reported that with categorized word lists, forgetting rates declined from grade 2 to 6 to 11 over a 1-week retention interval. Similarly, Howe (1987) reported age differences in forgetting over a 2-week retention interval where older children showed less forgetting than younger children for picture-word pairs. Further evidence for developmental differences in retention can be found in Brainerd et al. (1990) who had subjects remember either abstract or concrete nouns or pictures. They found that forgetting rates declined from grade 2 to 6 over a 2-week retention interval. Similar results have been reported for unrelated and related word lists (e.g., Howe et al., 1992) and for stories (e.g., Howe, 1991). Howe (1991) asked kindergarten and grade 2 children to recall stories after a retention interval of either 2 days or 9 days, and found less forgetting for the older children. In addition, forgetting seems to be related to semantic factors. For example, regardless of age, forgetting decreased for taxonomically related as opposed to unrelated materials (e.g., Brainerd et al., 1985; Howe, 1987; Howe et al., 1992).

To summarize, the main findings from the early forgetting research indicated no developmental differences in forgetting. However, this interpretation may be misleading because of methodological and procedural flaws of this early research (e.g., levels-of-learning confounds, use of recognition measures). More recently, researchers have addressed these concerns and have reported development differences in forgetting for a variety of ages and stimulus materials. Taken together, recent studies provide convincing evidence that forgetting rates decline with age.

Hypermnesia

Some early research indicated that memory performance improved with increasing retention intervals (Ballard, 1913). This work received very little attention initially, although it did raise several questions because of the well established Ebbinghaus forgetting function. This "hypermnesia" phenomenon was investigated to determine if it was a reliable finding, and if so, to establish the conditions under which hypermnesia versus forgetting occurred (e.g., Payne, 1987).

Ballard (1913) presented children with a variety of study materials, such as prose passages, and after various retention intervals, gave several recall tests without intervening study trials. He found that subjects' recall performance improved across repeated tests. Items not recalled on the first of two retention tests were successfully recalled on the second retention test, a phenomena Ballard labelled reminiscence. However, this improvement in performance was greater for younger as opposed to older children. Several researchers subsequently reported similar developmental findings (e.g., Ammons & Irion, 1954; Bunch, 1938; cited in Payne, 1987; Huguenin, 1914; Nicolai, 1922; Williams, 1926; all cited in Piaget & Inhelder, 1973, pp. 47-48; McGeoch, 1935). Nevertheless, there were difficulties with attempts to replicate this early research primarily because of inconsistencies in the definition of reminiscence, methodological inconsistencies across experiments, and confusion about the most appropriate theoretical explanation of this phenomenon (e.g., Payne, 1987; Wheeler & Roediger, 1992). As a result, interest in hypermnesia waned considerably and this topic essentially disappeared from the developmental literature. There are several excellent reviews of this early hypermnesia research (see Howe & Brainerd, 1989; Payne, 1987).

More explicit definitions and better controlled studies (e.g., levels-of-learning problem) has renewed interest in the hypermnesia phenomenon. Although some researchers have reported age-related hypermnesia effects in retention performance (e.g., Brainerd et al., 1985; Shaw, cited in Richardson, 1985), the most recent research indicated no developmental differences in hypermnesia. For example, Howe et al. (1992) reported no consistent developmental differences for hypermnesia for subjects ranging from grade 2 to college level for a variety of list conditions (related and unrelated pictures and words) and retention intervals (2 days, 16 days, 30 days). In addition, it is not clear under what conditions hypermnesia occurs. For example, some research has shown that hypermnesia is unaffected by semantic factors (among others) (e.g., Brainerd et al., 1985; Howe, 1987; Howe et al., 1992), whereas other research has shown that hypermnesia varies as a function of semantic factors (e.g., Brainerd et al., 1990).

To summarize, researchers have recently identified and corrected methodological problems that may have suppressed developmental trends in long-term retention (both forgetting and hypermnesia). This research indicates that there are developmental trends in forgetting, and that similar to memory acquisition, forgetting seems to be related to semantic factors (e.g., less forgetting for taxonomically related as opposed to unrelated materials). Further investigations of the hypermnesia phenomenon are necessary because the recent research has not so clearly identified developmental trends or important related factors. Research efforts should be focused on clarifying the conditions under which both forgetting and hypermnesia occur, with an emphasis on how these processes fit into the current formulations of the knowledge base framework.

C. Relationship Between Knowledge Base and and Long-Term Retention

Evidence for a relationship between knowledge base and long-term retention is essentially nonexistent. One exception is Chi and Koeske (1983), who reported enhanced long-term retention for a child tested with materials consistent with his current level of domain-specific knowledge. A child expert, knowledgeable about dinosaurs, recalled more about better known than lesser known dinosaurs, both at immediate recall and one year after the initial study. A number of methodological problems indicate caution in drawing conclusions based on these findings. For example, only one child was tested, and initial levels of recall performance were very low and were not equivalent for better and lesser known dinosaurs. The apparent forgetting of lesser known dinosaurs (compared to better known dinosaurs) after one year may have occurred because recall of these items was low initially (i.e., many items were not learned initially). From these results it is not clear if the knowledge base facilitates long-term retention or alternatively, if forgetting is independent of expertise (e.g., knowledge base).

The problem here is reminiscent of design limitations in more traditional memory research in which one learning trial is typically used, and is then compared with retention performance after some period of time. This is the levels-of-learning problem introduced previously. Easier information is learned at a faster rate than harder information, older children learn faster than younger children, and learning curves are negatively accelerated (e.g., Brainerd et al., 1985; Howe, 1987; Howe & Hunter, 1986). This means that at the end of acquisition, there will be levels-of-learning confounds with other variables of interest. Performance differences may be attributable to differences in the extent of learning easy and hard items, or because older children more completely learned a greater number of list items, and not due to differences in the variables hypothesized to account for performance.

From a knowledge base perspective this problem can be conceptualized as follows. Suppose that subjects high in knowledge (experts) and subjects low in knowledge (novices) are given a list of words to remember using a traditional research design of one or a few learning trials followed by a performance measure. Because experts learn expert-related information faster than novices (e.g., McCauley, Weil, & Sperber, 1976; Roth, 1983), at the end of the fixed number of study trials, more of the list items will have been learned by the experts. They will likely show better memory performance than the novices. Knowledge base theorists would likely predict that because experts remembered more on an acquisition test, they would forget less on a retention test. However, differences in initial learning may account for any predicted differences at retention. It is entirely possible that experts recall more (or forget less) because of differences in initial levels-of-learning, and not because of differences in knowledge base. Further, research using these traditional designs does not separate forgetting from hypermnesia. Because of these confounds, the existing research precludes determining how knowledge (if at all) influences long-term retention performance.

As before, the methodological solution to this problem is to have all subjects reach a prespecified criterion of performance on a given set of stimulus materials. This type of control should be implemented to minimize initial differences in original level of learning for groups that differ in memory ability (such as experts versus novices or older versus younger children) and for materials that potentially vary in difficulty (Howe, 1987). This dissertation research and a study by Clark and Howe (1990) are examples of knowledge base studies that overcome the levels-of-learning problem. We ensured that all subjects reached a criterion of perfect recall on 2 consecutive trials at acquisition. This procedure is important to bring all subjects to similar learning levels because with single trial designs, many of the items are likely to not have been learned. Given this methodological control, one can then investigate the uncontaminated effects (i.e., no levels-of-learning confounds) of the knowledge base on long-term retention performance. The importance of using multiple trial designs has also become evident recently for studying other aspects of memory development. For example, Bjorklund (1988) and Bjorklund and Buchanan (1989) have reported that strategy use is apparent for both younger and older children after several exposures to the stimulus materials, whereas with single-trial designs, even children aged 10-13 years have been classified as non-strategic. These findings suggest that conclusions about the development of memory strategies will vary as a function of the number of learning trials administered.

With differences in learning controlled for, the Clark and Howe (1990) study indicated that the relationship between knowledge and long-term retention is worthy of attention, and does not simply parallel the acquisition findings. They tested memory acquisition and long-term retention performance for expert versus novice children when knowledge was equated (neutral stories) and not equated (experts stories). Presentation of the neutral materials served as a control to determine if experts were inherently better at remembering. The main question of interest was whether the use of knowledge consistent with a child's level of conceptual development enhances long-term retention (reduced forgetting and promoted hypermnesia).

Twenty children who attended a biology summer camp (experts in biology) and 20 age- and sex-matched novices (who did not attend the summer camp) learned passages to criterion performance (matched for difficulty) in the area of expertise (biology) and an area of nonexpertise (a passage about the solar system). Both passages were within the grade level of the children. Objective multiple choice tests were used to measure level of expertise (one on biology, one on the solar system). Two weeks following acquisition, long-term retention was measured using a 4-trial free recall test.

Consistent with previous findings, Clark and Howe (1990) found that expert subjects learned the expert passage faster than novices and faster than the neutral passage. More important, at long-term retention, experts forgot less than novices. There were also some curious results evident in the Expertise X Story interaction. Compared to experts, novices forgot more from the neutral story, but there was no expert-novice difference in forgetting for the expert story. In addition, the results of this study indicated that overall, errors decreased across trials, suggesting that hypermnesia occurred. The long-term retention findings showed that forgetting does vary with expertise, and although hypermnesia occurred, it was constant across expertise. The Clark and Howe study provided evidence that the contribution of the knowledge base to long-term retention deserves attention. For example, the findings suggest that the knowledge base, (1) may influence acquisition and long-term retention in different ways and, (2) effects may vary as a function of whether forgetting or hypermnesia is measured.

D. Research Questions

Several major questions need consideration to further our understanding of the contribution of knowledge and age to the development of memory acquisition and long-term retention processes. Specific questions addressed in this research are listed here and elaborated below. First, is knowledge structured the same way for experts regardless of age? For example, do older and younger experts have similarly elaborated and integrated domain-specific knowledge? Second, does knowledge influence acquisition and retention processes similarly? Third, in terms of long-term retention performance, how do forgetting and hypermnesia processes relate to knowledge manipulations? Fourth, is acquisition and retention performance better when tested with materials consistent with current level of domain-specific knowledge?

Research Question One

Investigators have assumed that once a child reaches the status of expert in a given domain, their knowledge representation is similar to other experts in that area regardless of age. It is important to investigate this empirically, however, given the suggestion that developmental changes in knowledge include changes in structure. We do not know that once expertise has been reached knowledge is similarly integrated, elaborated, and cohesive (e.g., structured), regardless of age. In addition, we do not know if knowledge representation differences also exist for children with varying levels of expertise. Given the evidence for age-related differences in conceptual knowledge, it is important to ascertain whether there are similar age- and/or expertise-related differences in knowledge for an area of expertise (similar to concept development in semantic memory).

Further, if differences in knowledge structure do exist, do they influence memory processes such as the acquisition and retention of information, as suggested earlier. Bjorklund et al. (1983) have argued that the use of adult-defined word lists with children results in a confound between differences in information processing and age differences in knowledge. Any time differences in knowledge are possible, as may be the case with different age children with expertise in an area, researchers should consider that this may be a confounding factor in studying developmental changes in cognitive processing. The answer to this first research question is most important as a link to the research questions pertaining to memory processing - the main focus of this dissertation. If there are age-related differences in expert knowledge, similar to semantic memory research, these differences should be taken into consideration when determining the most appropriate stimulus materials to study long-term retention performance in a developmental study of experts and novices.

The structure of knowledge was investigated by having children tell stories in their area of expertise. It was assumed that the quality of the stories told in terms of structure (inclusion of story parts and connections among them) is a reflection of knowledge representation. This is similar to research discussed previously that investigated the structure of knowledge of dinosaurs (Chi & Koeske, 1983; Gobbo & Chi, 1986). Gobbo and Chi measured the use of connecting words such as "because" and "if" as indications of structure for a task where children were asked to tell everything they knew about dinosaurs. In this dissertation, story grammars were used as a measure of the structure of domain-specific knowledge. Specifically, a child generated a story, it was scored according to a story grammar, and was then classified as to its structural quality (e.g., poor versus well structured). Inferences about that child's knowledge representation for the domain under investigation were then made based on the story grammar rating.

Story Grammars

Story grammars describe the underlying cognitive structures used to encode, represent, and retrieve story information (Rumelhart, 1975). This review of the basic assumptions underlying the construction of story grammars is based primarily on Stein and Glenn (1979) and Mandler and Johnson (1977) as well as Johnson and Mandler (1980), whose work is most often referred to and used in this area. This literature is reviewed because it is the basis for the story grammar used in the analysis of children's story productions in this dissertation research. The two main types of stories described by story grammars are goal-based and nongoal-based stories. Although story grammars was the best means of analyzing story structure here, partly because this is most commonly used for expertise research with stories and partly because the majority of stories told were easily described by this grammar, there are additional measures (e.g., Labov's high-point analysis) that may be used with a different type of story (e.g., McCabe & Peterson, 1984).

According to several researchers (e.g., Mandler & Johnson, 1977; Stein & Glenn, 1979 ; Stein & Policastro, 1984) a prototypical goal-based story has six major constituents that refer to the major structural characteristics of stories. These include a(n), (1) setting, (2) initiating event, (3) internal response, (4) attempt, (5) consequence, and (6) reaction. The setting is the introduction of the protagonist, and information about the physical, social, or temporal context for the story. The remaining categories together constitute an episode. The initiating event contains information about some type of change in the protagonist's environment. Its major function is to evoke in the protagonist an emotional response and a desire to achieve some goal. The internal response includes goal information, change of state information, and also can include the protagonist's thoughts and plans about how to attain a goal. The major function is to motivate the protagonist to carry out an action(s) directed toward a goal. The attempt is the protagonist's actions to attempt to obtain the goal, and the consequence is the outcome of the attempt. The reaction or ending may include the protagonist's emotional/cognitive responses to the goal attainment, long-term consequences that occur as a result of attaining the goal, moral, and/or a summary of what the protagonist learned from pursuing a particular goal. In addition, direct causal and temporal connections must link the five episode categories.

To be classified as a story all five parts of an episode do not have to be included. However, according to Stein and Glenn (1979) and Mandler and Johnson (1977), certain features must always be present in text structure for a meaningful representation of a story. According to these researchers a story must contain: (1) setting, including introduction of an animate character, (2) initiating event or internal response containing information from which the motivations, goals, and emotional response of the protagonist can be inferred, (3) overt attempt of the protagonist or plan outlining the overt attempt, and (4) consequence reflecting whether the goal has been attained.

The second type of story described by a story grammar is the nongoal-based story, which does not describe the overt actions of someone to attain a goal. In nongoal-based stories the protagonist is engaged in an action, rather than in an attempt to reach a goal. For example, this type of story may begin with an event that changes the protagonist's environment (the King was walking in the woods with his daughters), indicate an emotional response and unplanned action (they were enjoying themselves so much they forgot the time), and finish with an ending (they were kidnapped by a dragon) (Mandler & Johnson, 1977; Stein & Policastro, 1984). Mandler and Johnson (1977) define nongoal-based stories as stories that allow for the unplanned, automatic actions to form part of the episode. Nongoal-based stories are similar in structure to goal-based stories. They include a(n), (1) setting, introduction of the protagonist, (2) beginning (similar to Stein & Glenn's initiating event),

(3) protagonist's emotional response to the initiating event, (4) automatic unplanned action resulting from feeling a particular emotion, and (5) ending (similar to Stein & Glenn's reaction category).

To summarize research question one, an objective of this dissertation was to investigate whether age-related differences in knowledge structure (in this case stories) disappeared once a child becomes an "expert" in an area. In addition, the present research directly addressed the question of whether differences in levels of expertise were also tied to knowledge structure changes and how this related to age. It is unclear whether younger expert children would generate stories with fewer story parts, and/or stories with few or no temporal and causal links. Alternatively, perhaps expertise in an area signals more elaborate knowledge representation in terms of the production of a more prototypical story. In this case developmental differences would be minimized. The findings of this preliminary study were critical for the primary research of this dissertation - a developmental study of memory processing in children with different levels of expertise. The stories generated in this study served as the source of materials used to study memory processing.

Research Questions Two, Three, and Four

The remaining questions addressed in this dissertation pertained directly to the effects of knowledge on memory acquisition and long-term retention performance. To reiterate, these questions were: does the knowledge base influence acquisition and retention performance similarly, how do the long-term retention processes forgetting and hypermnesia relate to knowledge base manipulations, and is acquisition and retention performance better when tested with materials consistent with current levels of domain-specific knowledge?

General theories of memory development, specifically knowledge base models, rely on the notion that it is easier to access well encoded, as opposed to less well encoded information on a memory test (e.g., Bjorklund, 1987; see also Bjorklund, 1985; Bjorklund & Zeman, 1982; Chi, 1978; Chi & Rees, 1983; Ornstein, Baker-Ward, & Naus, 1988; Ornstein & Naus, 1985). Based on knowledge base research, one may predict that similar to acquisition, elaborated knowledge may lead to less forgetting. One could speculate that retrieval should also be more efficient on a long-term retention test for well integrated information. This leads to the assumption that knowledge is a factor that facilitates both memory acquisition and retention processes. Chechile and Richman (1982) suggested that forgetting decreases as information in the knowledge base becomes more extensively integrated. They also reported that well-encoded information such as highly meaningful materials are more resistant to forgetting.

These assumptions lead to the implication that what is good at acquisition is also beneficial for long-term retention. In other words, the benefits of knowledge (e.g., domain-specific expertise) that typically occur for the initial learning of information, will also occur for retention. Children more knowledgeable in an area will remember more information over time than children less knowledgeable in that area. This outcome would suggest that memory acquisition and long-term retention processes are symmetrical with respect to the effects of knowledge on memory performance. An explanation for this outcome may be that memory traces, while cohesive, were not as well integrated (qualitatively) originally for low expert subjects. This would support the argument that knowledge does have an effect in preventing the demise of traces over a long-term retention interval. This would also be consistent with the implications of the general theories of memory regarding the effects of knowledge on memory processing.

An alternative scenario is that the effects of knowledge at acquisition do not occur at long-term retention. There may be no differences in rate of forgetting for children with different levels of prior knowledge. This type of outcome would suggest that knowledge may influence acquisition and long-term retention in different ways, specifically, knowledge effects are confined to acquisition processes.

In terms of long-term retention processes specifically, Howe et al. (1992) provided data showing that "regardless of age, forgetting was attenuated by the presence of features that bind elements of traces together (e.g., related vs. unrelated items)" (p. 64). Because experts have well elaborated knowledge (expertise) in an area, that should allow easier access to information resulting in better performance on a long-term retention test. However, this may depend on whether subjects are tested with materials consistent with their level of expertise or knowledge representation. As the acquisition research showed, it is important to use age-related materials to provide a knowledge base assessment independent of age differences in memory. If it is important to use expertise-consistent materials to study memory processing, one would also expect to see an Expertise X Storytype interaction at long-term retention. Children with different levels of expertise should have better retention for stories structured in a manner consistent with their current level of knowledge representation. Knowledge manipulations may also interact with age at long-term retention, as seen in an Age X

Storytype interaction. This should indicate that retention is best for age-related stories. The alternative outcome is that this trend is important only at acquisition.

In addition to forgetting, long-term retention involves hypermnesia (e.g., Howe & Brainerd, 1989). Previous research has reported no consistent developmental differences in hypermnesia, and relative to forgetting, the effects of hypermnesia are small. In addition, although multiple trial testing is important to see hypermnesia effects, it is a procedure only recently utilized (e.g., Brainerd et al., 1985; Howe et al., 1992). Based on the findings of previous research, one implication for the current research is that there are similar amounts of hypermnesia for high and low expert children regardless of knowledge base manipulations.

Alternatively, consistent with knowledge base explanations, there may be differences in hypermnesia for the high versus low expert subjects. There may be greater gains for high expert children over the retention trials due to better initial integration of memory traces. Because memory traces are more highly integrated for the high expert group, they may retrieve these traces more easily on a retention test. With each retrieval attempt making connections with more traces, recall increases over the retention interval. Hypermnesia occurs for high but not low expert subjects. Again, this effect may vary with the type of materials used (e.g., consistent with current level of domain-specific knowledge base development).

To summarize research questions two through four, the main objective of this dissertation was to investigate the effects of differences in knowledge on the development of both memory acquisition and long-term retention processes. The present research addressed the question of whether memory acquisition and retention processes are symmetrical with respect to the effects of knowledge on memory performance. Further, it is unclear whether forgetting and hypermnesia will vary in a similar manner as a function of knowledge. Finally, acquisition and long-term retention performance may depend on whether subjects are tested with materials consistent with their level of expertise. Consistent with acquisition research and the use of age-related materials, this research investigated if children have better retention for stories consistent with their current level of knowledge representation.

E. Overview of Experiments I and II

The purpose of the first experiment was to investigate the structure of knowledge as measured by story production for children of different ages and levels of expertise, knowledgeable about the sport of soccer (Experiment IA) or tennis (Experiment IB). It has proved important in other knowledge base research (e.g., semantic concepts) to study cognitive functioning with materials rated by same-aged subjects. This has not been done in studies investigating the effects of expert-novice knowledge on memory processing. It has simply been assumed that experts of all ages have similarly integrated and elaborated information. Thus, Experiments IA and IB will determine if this assumption is accurate, and the stories produced in these experiments will be used in Experiment II to investigate the effects of domain-specific knowledge on memory processing.

Children of different ages generated stories in their area of expertise. Expertise was assessed by a questionnaire based on existing assessment tools used for determining level of expertise (e.g., Cheisi, Spilich, & Voss, 1979; Recht & Leslie, 1988; Schneider et al., 1989). The structure of the stories was compared for children of different ages and varying in expertise level. It was assumed that story structure is a reflection of knowledge representation. Story structure was analyzed with a story grammar designed for this research that is based on existing story grammars (e.g., Mandler & Johnson, 1977; Stein & Glenn, 1979; Stein & Policastro, 1984). Specifically, stories were analyzed for the types of elements making up the story (story categories such as setting) and the types of relations between them (such as causal and temporal). If the structure of the stories was the same for different aged subjects, this would suggest that expert knowledge is similar regardless of the age of the expert. If the structure of the stories varied with age, this would provide evidence that similar to previous research on the knowledge base (e.g., Bjorklund, 1987; Bjorklund & Thompson, 1983; Bjorklund et al., 1983; Bjorklund & Zeman, 1983; Clark, 1989), age-appropriate materials may be required to investigate memory processing differences between experts of different ages. A similar interaction could occur with level of expertise (e.g., Expertise X Knowledge Structure). In other words, observed differences in story structure may depend not only on age, but also on expertise.

The purpose of Experiment II was to investigate the influence of knowledge on acquisition and long-term retention performance for different aged children with varying levels of expertise in soccer. The soccer questionnaire used in Experiment IA was re-employed here to assess expertise. Given that there were differences in the structure of the children's stories as a function of age and level of expertise in Experiments IA and IB, one can assume that the nature of knowledge for different aged experts is not the same. The influence of these differences in expert knowledge on memory functioning, particularly long-term retention, was investigated. Children memorized a story, which came from those generated in Experiment IA, that reflected these differences in expert knowledge.

Stories representative of those generated by children with different levels of expertise (specifically low and high levels of expertise) were presented to both younger and older children with either high or low expertise. This procedure allowed me to assess the ability of different aged experts to process information characterized by either more or less expert children. For semantic memory information, previous research has shown that with age-appropriate knowledge bases, younger children outperform older children on tests of memory (e.g., Bjorklund, 1987; Chi, 1978). It is unclear if this same effect occurs with experts. Age X Knowledge Base interactions were investigated for both acquisition and long-term retention performance. To investigate this, there were four groups of subjects factorially combined for the factors of Age and Knowledge Base, resulting in the following groups: younger/high knowledge experts, younger/low knowledge experts, older/high knowledge experts, and older/low knowledge experts. This control allowed me to dissever the contribution of age and knowledge base factors to memory performance, both acquisition and long-term retention.

CHAPTER II

EXPERIMENTS IA AND IB: STORY STRUCTURE AND KNOWLEDGE BASE

The purpose of these two experiments was first, to provide stimulus materials for Experiment II, and second, to determine if the structure of domain-specific knowledge differs for subjects of different ages and with different levels of expertise. Subjects, knowledgable about soccer (Experiment IA) or tennis (Experiment IB) generated stories rather than the typically used word lists to obtain a more comprehensive representation of expert knowledge. It was assumed that the structure of the stories would provide information regarding the representation of knowledge.

Experiment IA

Method

Subjects

The children were randomly selected to participate from a pool of approximately 300 children registered in the St. John's Minor Soccer Association League. After receiving executive committee approval from the St. John's Minor Soccer Association League the parents were telephoned, given an overview of the study, and asked if they would agree to their child participating. Those children whose parents returned a signed parental consent form indicating that their child could participate were included in the sample. A total of 240 male children ranging in age from 6 to 14 years participated in Experiment IA. However, some children did not provide data, and some data were unusable because of equipment malfunctions. This resulted in 213 subjects used in the final analysis, with the following age breakdowns: 13 6-year-olds (M = 6.4, SD = 5.1), 21 7-year-olds (M = 7.5, SD = 3.8), 29 8-year-olds (M = 8.5, SD = 3.1), 20 9-year-olds (M = 9.3, SD = 2.9), 31 10-year-olds (M = 10.4, SD = 3.8), 27 11-year-olds (M = 11.5, SD = 3.7), 34 12-year-olds (M = 12.5, SD = 3.8), 29 13-year-olds (M = 13.4, SD = 3.7), and 9 14-year-olds (M = 14.1, SD = 2.0).

Materials

Stimulus materials consisted of a questionnaire adapted from previous research in this area (Cheisi, Spilich, & Voss, 1979; Recht & Leslie, 1988; Schneider, Korkel, & Weinert, 1989). A 37 item questionnaire, referred to as the pretest, was used to assess children's knowledge about soccer. The questions (primarily multiple choice) consisted of knowledge of the rules of the game, terminology, and the principles of the game. For example, the questionnaire included the following types of questions: "Which team has the kick-off to start the match?", "The technique of heading means?", and "Who decides if a goal has or has not been scored?" (Refer to Appendix A for the complete questionnaire). Two coaches of the St. John's Soccer Association, plus several acquaintances who have played soccer in organized associations for many years, agreed on the appropriateness of the questions to assess soccer knowledge. Other materials included a taperecorder.

Procedure

Subjects were tested individually in a quiet room either in their home or in an office at the university. Each subject received a booklet of the pretest questions. The experimenter instructed subjects to read each question and indicate the correct response. For the younger subjects, the experimenter read along with the children as they proceeded through the pretest. The score on this pretest was converted into a percentage correct that reflects level of expertise for soccer knowledge. After completion of the pretest, the subjects were asked to tell the experimenter a story about soccer, which was tape recorded and later transcribed. Subjects received no other prompting. The entire session lasted approximately 40 minutes.

Story Grammar Scoring

The scoring system used to analyze the protocols generated from the subjects (see Table 1) was based on criteria from Fitzgerald, Spiegel, and Webb (1985), Johnson and Mandler (1980), Mandler (1987), Mandler and Johnson

Table 1. Definition of the Seven Levels of Story Structure.

Label	Definition
1 Scripts	They involve a routine to be followed rather than a problem to be solved, or they involve a general event description consisting of a sequence of acts. They generally predict and describe what happens (Nelson, 1986).
2 Descriptive Sequences	A series of descriptions of objects or events and some story categories. They have no goal-based structure, and no or few causal connections between statements (e.g., Fitzgerald, Spiegel, Webb, 1985; Stein & Glenn, 1977).
3 Reactive Sequences	A series of descriptions of objects or events and some story categories. They have no goal-based structure, but include some causal connections between statements (e.g., Fitzgerald et al., 1985; Stein & Glenn, 1977).
4 Nongoal-based Stories	They include some story categories, but have no indication of goal-based structure. Episodes include an initiating event that have significance for the protagonist, and includes an emotional response and unplanned action (e.g., Johnson & Mandler, 1980; Mandler & Johnson, 1977; Stein & Policastro, 1984).
5 Abbreviated Episodes	A goal-based structure is present or implied. There are some, but not all story categories present (e.g., setting, initiating event, ending etc.) (e.g., Fitzgerald et al., 1985; Stein & Glenn, 1977).

6	Goal-based Stories	They include a goal-based structure with all six story categories present (e.g., Fitzgerald et al., 1985; Mandler & Johnson, 1977; Stein & Glenn, 1977; Stein & Policastro, 1984).
7	Goal-based Stories with multiple episodes	They are the same as goal-based stories with more than one episode (e.g., Fitzgerald et al., 1985; Stein & Glenn, 1977).

(1977), Nelson (1986), Stein (1979), and Stein and Policastro (1984). They have outlined means of investigating the structure of narratives generated by children. Scoring the present protocols based on these criteria first corroborated the general classifications made and second permitted a determination of lesser and better structured stories.

Scripts were included as a category because a small number of children did produce scripts rather than stories. A script refers to a general event description consisting of a sequence of acts that involve a routine to be followed rather than a problem or episode. In addition, scripts often do not include specific characters, or time or place information (e.g., Nelson, 1986). Alternatively, a story includes information about characters, setting, a problem or focus of the episode, and outcomes (e.g., Stein & Glenn, 1979).

Consistent with the research reviewed previously, stories with all parts of an episode and causal and/or temporal links were scored as well structured. Those containing permissible deletions of any category of information were considered as poorly structured. For example, a poorly structured story, classified as a Descriptive Sequence, was a story with story categories missing, and with no causal connections between propositions. A well structured story (classified as a Goal-Based Story) included the 6 story categories, a goal structure, and causally and temporally connected propositions. As seen in Table 1, stories were scored according to 7 levels of story structure. A higher rating of story structure refers to a better story structure, with two notable exceptions of Scripts and Nongoal-based Stories because they are qualitatively different from the other categories. Thus, an increase from least to best structured story corresponds to the story levels 2, 3, 5, 6, and 7. Two individuals rated the stories, with an interrater reliability of 92%, and any differences were resolved through discussion. (Refer to Appendix B for examples of each type of story).

In addition, each story was scored for content on a 4 point scale, which refers to the actual propositions that made up the stories. Recall from the previous discussion on page 5 that content and structure can be differentiated in that structure refers to the pattern of the information (in this case the parts and connections of a typical story), whereas content refers to the information (or topics) contained within the structure. For example, content is what the story was about, such as a description of a person, or telling about a soccer game. The four types of content scored were (1) description of object, person, or event, (2) description plus some soccer game information, (3) primarily soccer game information plus some description, (4) soccer game information. Unlike structure, for content a score of 4 is not "better than" a score of 1. The levels of story structure (excluding Scripts because by definition they are only of one content type) were crossed with each of the four levels of content.

Design and Analysis

Overall knowledge of story structure was investigated with a stepwise multiple regression analysis with the production scores from 1 to 7 (Story Structure) as the dependent variable, and Age, Expertise, and Story Content as the independent variables. Age and Expertise were both continuous variables. Age was measured in months and ranged from 69 to 174 months (5.9 to 14.6 years) and Expertise was measured as the score on the pretest converted into a percentage and ranged from 24 to 97 percent. Story Content was measured as a score of 1 to 4. Additional analyses were done to investigate the mean level of Age and Expertise for each type of Story Structure, and the number of each type of Story Structure generated. A second regression analysis was performed with Story Content as the predicted variable with Age, Expertise, and Story Structure as the possible predictor variables. Finally, a supplementary analysis was conducted on the number of story categories generated at each age level.

Results and Discussion

Regression with Story Structure

Table 2 shows the correlations between the variables, the unstandardized regression coefficients (B) and intercept, the standardized regression coefficients (b), as well as the values of R, R^2, and adjusted R^2 with Story Structure as the dependent variable. R for the final regression equation was significantly different from zero, $F(2, 210) = 54.64$, $p<.001$. Only two of the independent variables, Expertise and Age, contributed significantly to the prediction of Story Structure. Expertise (t-value = 9.84) entered the equation first, Age (t-value = 2.97) entered second. After step 1, with Expertise in the equation, $R^2 = .31$, $p<.001$, and after step 2 with Age added to the prediction of Storytype, $R^2 = .34$, $p<.001$, indicating that the addition of Age to the equation resulted in a significant increment in R^2. There were no significant interactions, which was evaluated by a semi-partial correlation or increment-in-variance test (e.g., Kerlinger & Pedhazur, 1973; Tabachnick & Fidell, 1989) that indicated the variance which is uniquely associated with the interaction is nonsignificant. Despite their high interrcorrelation ($r = .79$), Age and Expertise each contributed independently to predicting Story Structure.

Table 2. Multiple Regression with Age, Expertise, and Content Variables on Knowledge of Story Structure for Soccer.

Variables	Structure(DV) B^a	b^{aa}
Age	.0171*	.27
Expertise	.0378*	.35
Content	.0943	
	Intercept=-.43	

Multiple R = .59
R^2 = .34
Adjusted R^2 = .33

Correlations

	Structure (DV)	Age	Expertise	Content
Structure	1.00	.55	.56	.31
Age	.55	1.00	.79	.40
Expertise	.56	.79	1.00	.36
Content	.31	.40	.36	1.00

Means and Standard Deviations

	Structure(DV)	Age	Expertise	Content
Mean	4.2	126	67.4	2.8
SD	1.7	27.3	15.8	.98

[a] B - unstandardized regression coefficients
[aa] b - standardized regression coefficients
* $P<.01$

Low expert children generated poorly structured stories and high expert children generated well structured stories, but they could be either younger or older children. Although narratives develop, expertise is more highly related to story structure. These findings suggest that there are age- and expertise-related differences in knowledge in terms of story structure. In other words, this study provides evidence that there are differences in the structure of knowledge for children of different ages and who have different levels of expertise (e.g., some expertise, more expertise,.

<u>Mean Age and Expertise For Story Structure</u>

The second analysis (Tukey-HSD procedure) was conducted on the means for Age and Expertise for the 7 levels of Story Structure. As can be seen in Table 3, with greater age and expertise well structured stories were generated. In other words, older children tell better structured stories than younger children, as do children with more expertise compared to children will less expertise. Further, for Age, there were significant differences ($p<.05$) between Story Structures 1 vs. 7; 2 vs. 5,6,7; 3 vs. 5,6,7; and 4 vs. 7. For Expertise, there were significant differences ($p<.05$) between Story Structures 1 vs. 5,6,7; 2 vs. 5,6,7; 3 vs. 5,6,7; and 4 vs. 7. This analysis showed that there is a natural division between Story Structures for Age (age

Table 3. Average Age and Expertise for Each Type of Story Structure for Soccer.

Story Type	Age	Expertise	
	M	M	SD
1	114	55.0	14.4
2	104	55.7	11.8
3	112	58.1	16.0
4	116	62.2	15.5
5	136	74.4	10.6
6	139	75.1	14.5
7	150	80.3	4.4

1 = Script
2 = Descriptive Sequence
3 = Reactive Sequence
4 = Nongoal-based Story
5 = Abbreviated Episode
6 = Goal-based Story
7 = Goal-based Story with multiple episodes

approximately 9 years 0 months = Descriptive/Reactive Sequences vs. age approximately 11 years 10 months = Goal-based Stories). Specifically, younger children were most likely to generate a poorly structured story such as a Descriptive or Reactive Sequence, whereas by age 11 or 12 years, children were most likely to generate a better structured story such as Goal-based Story.

This change in story production between ages 9 and 11 is similar to a developmental shift in the structure of self-generated stories reported in the literature (e.g., Fitzgerald et al., 1985; Salatas Waters & Hou, 1987). For example, Salatas Waters and Hou asked third and sixth graders and college students to generate passages based on a set of prompt words defining the topic. Passages were assigned a score from 1 to 7 that included distinctions between the presence of no/few causal/temporal connections to more causal/temporal connections and an increasing use of episodic structure. They found significant differences in production scores for third and sixth graders, and no differences between sixth graders and college students. The third grade passages included primarily temporal connections or an inconsistent use of temporal and causal connections, whereas the sixth grade passages included more causal connections.

A similar trend occurred for children with less and more soccer expertise. There was a division between Story Structures for Expertise (expertise approximately 57% = Descriptive/Reactive Sequences vs. expertise approximately 76% = Goal-based Stories). Specifically, children with little expertise (or novices) generated poorly structured stories compared to those with more expertise (or experts), who generated better structured stories. Experts, it seems have a better representation of domain-specific knowledge than novices.

The findings of the present research provide evidence that as age or expertise increases, the structure of knowledge changes. Based on these results, the assumption that experts of all ages have similarly integrated and elaborated information should be questioned. Clearly, developmental differences in knowledge representation are not eliminated when expertise is controlled. In other words, expertise in itself does not signal a standard structure for the representation of information.

Given that the structure of knowledge varies with age and expertise, and given the findings of the previous research regarding Knowledge Base X Age confounds (e.g., Bjorklund, 1987; Bjorklund & Thompson, 1983; Bjorklund, Thompson, & Ornstein, 1983; Bjorklund & Zeman, 1983; Clark, 1989), there may be processing differences between children with different levels of expertise on materials that reflect differences in knowledge representation. There is evidence to indicate that memory processing is facilitated when tested with materials consistent with knowledge base development (Bjorklund, 1987; Bjorklund & Thompson, 1983; Bjorklund et al., 1983; Bjorklund & Zeman, 1983; Clark, 1989). It is not clear if this facilitory effect would occur for children with both high and low expert knowledge tested with materials consistent with knowledge representation (e.g., either poor or well structured stories) in their domain of expertise. This question was addressed in Experiment II.

Number of Passages by Story Structure

There were very few passages generated as Scripts (6/213), Nongoal-based Stories (9/213), or Goal-based Stories with multiple episodes (10/213) (see Table 4 for the number of stories generated for each story structure). These data indicated that, consistent with Stein and Policastro (1984), children were more likely to generate passages rated as stories rather than scripts. This is in contrast to Nelson (1986) who claimed that most younger children produce Scripts when asked to generate stories.

Regression with Story Content

The second regression analysis with Story Content as the predicted variable was conducted to investigate the relationship between story structure and content. This

Table 4. Total Number of Passages Generated for Each Type of Story Structure for Soccer (Percentages are in Brackets).

1	Scripts	6	(3%)
2	Descriptive Sequences	45	(21%)
3	Reactive Sequences	33	(15%)
4	Nongoal-based Stories	9	(4%)
5	Abbreviated Episodes	49	(23%)
6	Goal-based Stories	61	(29%)
7	Goal-based Stories with multiple episodes	10	(5%)
	Total	213	(100%)

analysis showed that Age was the only factor that significantly contributed to the prediction of Story Content. R for the regression was significantly different from zero, $F(1, 211) = 40.05$, $p<.001$ ($R = .40$, $R^2 = .16$, adjusted $R^2 = .15$). The correlation between Age and Content was $r = .40$. This relationship was further probed by calculating the number of children from each age level that generated stories from each of the four types of content (see Table 5). A Chi-square analysis ($p<.005$) revealed that a similar proportion of children of different ages generated passages from the 4 content categories, with the exception of the 6- and 7-year-olds. A similar proportion of children from ages 8 to 14 most frequently generated passages about a soccer game, or a soccer game with some descriptive information. The 6- and 7-year-olds' passages were primarily descriptive in content.

These results are consistent with Fitzgerald et al. (1985) who found in their analysis of story content few developmental trends in changes of content knowledge. Similarly, Stein, Glenn, and Jarcho (1982) (cited in Fitzgerald et al., 1985) reported no developmental changes in the thematic content of story productions of children in Kindergarten, Grade 3, and Grade 5. In the present research, content knowledge per se did not change with age between 8 and 14 years, however, age- and expertise-related

Table 5. Number of Children from Each Age that Generated Each type of Story Content for Soccer (Percentages are in Brackets).

	Age								
	6	7	8	9	10	11	12	13	14
Content[a]									
1	8	11	2	1	1	2	1	4	0
	(62)	(52)	(7)	(5)	(3)	(7)	(3)	(14)	(0)
2	2	9	8	2	5	0	3	2	0
	(15)	(43)	(28)	(10)	(16)	(0)	(9)	(7)	(0)
3	2	1	10	12	14	14	20	14	7
	(15)	(5)	(34)	(60)	(45)	(52)	(59)	(48)	(78)
4	1	0	9	5	11	11	10	9	2
	(8)	(0)	(31)	(25)	(36)	(41)	(29)	(31)	(22)

[a] 1 = Description of object, person, or event
2 = Description plus some soccer game information
3 = Primarily soccer game information plus some description
4 = Soccer game information

differences were observed in the way in which the content was structured. This finding is important for investigations of memory processing of passages to ensure age or expertise differences are due to structural and not content differences in the stories. Because the 8- to 14-year-olds' stories were of similar content, developmental differences attributable to structural differences in knowledge can be determined.

Supplementary Analysis

An additional analysis was conducted on the number of story categories such as setting, initiating event, attempt, consequence, ending etc. for Age, to examine developmental patterns in the inclusion of categories in generated stories. Fitzgerald et al. (1985) reported age differences in the number of story categories generated, which they suggested was one indication of developmental changes in knowledge of story structure. Following the procedure used by Fitzgerald et al. (1985), for each age level, the number of settings, initiating events, attempts, consequences, and reactions was calculated for those stories classified as an Abbreviated Episode, Goal-based Story, or Goal-based Story with multiple episodes. The present findings showed that consistent with Fitzgerald et al. (1985), there were age-related increases in the number of story categories. However, this finding must be interpreted with regard to story length. In this study, older children told longer stories, which may account for the observed age differences. If the question of interest is determining precisely where these age differences are located (e.g., is the age trend because older children include more settings than younger children, for example), then one would want to look at the proportion of categories generated for each age level. A Kruskal-Wallis analysis indicated that there were no significant age differences in the proportion of categories generated in each story ($p>.05$). These findings indicate that while there were age trends in the number of categories generated (e.g., Fitzgerald et al., 1985), there were no systematic age changes in the inclusion of the different story categories in self-generated stories.

Summary of Experiment IA Results

The main findings from this study indicated that there are independent age- and expertise-related changes in the structure of domain-specific knowledge. Having expertise in a domain does not automatically indicate that knowledge is represented similarly regardless of age. In addition, young children's knowledge representations change with age to become better structured. A transition occurs at approximately 11 years of age in that better structured stories are generated. A similar transition occurs when expertise levels become relatively high (i.e., approximately

76% based on a questionnaire to assess expertise). Children with a high level of expertise generated better structured stories compared to children with lower levels of expertise (i.e., about 57% based on a questionnaire). These findings may be interpreted as indicating that a developmental- or expertise-related change in knowledge structure is evident as children approach adult-like conceptions of knowledge, and as relatively high levels of expertise are reached. In addition, this study indicated that after age 8 and up to late childhood (age 14), self-generated stories in a domain-specific area do not differ in content. Given that there were age- and expertise-related differences in the structure, but not content of domain-specific knowledge, the influence of the structure of knowledge, independent of content, on memory performance in expert versus novice children was investigated in Experiment II.

Experiment IB

This study was identical to the first except subjects were knowledgable about tennis. The purpose of this study was to replicate the findings of Experiment IA for a different area of expertise to ensure that the findings of the first experiment were not simply related to a single knowledge base domain. There are contradictory reports in the literature as to whether or not there are qualitative changes in knowledge representation between younger and older experts for different domains of expertise (e.g., Means & Voss, 1985; Schneider, Korkel, & Weinert, 1990). The objective of this experiment is to determine if the age- and expertise-related changes in knowledge representation seen in Experiment IA generalize to another domain.

Method

Subjects

The children were randomly selected to participate from a pool of approximately 100 children registered in the St. John's Greenbelt Tennis Club Summer Program. After obtaining Tennis Club approval, the children were given a written overview of the study and a parental consent form for their parents. The sample consisted of children who returned a signed parental consent form indicating permission to participate. A total of 40 male and female children ranging in age from 7 to 13 years participated in Experiment IB. However, some children did not provide data, and some data were unusable because of equipment malfunctions. This resulted in 29 subjects used i . the analysis, with the following age breakdowns: 3 7-year-olds (male, M = 7.6, SD = 6.0), 2 9-year-olds (1 male, 1 female, M = 9.4, SD = 4.2), 7 10-year-olds (3 male, 4 female, M = 10.4, SD = 3.8), 7 11-year-olds (5 male, 2 female, M = 11.7, SD = 2.6), 8 12-year-olds (3 male, 5 female, M = 12.2, SD = 2.6), and 2 13-year-olds (female, M = 13.1, SD = 2.1).

Materials

Similar to Experiment IA, a 35 item questionnaire was used to assess children's knowledge about tennis (see Appendix C). The multiple choice questionnaire was adapted from sample examination questions from the Official Instructor's Manual for Tennis. In addition, the soccer questionnaire served as a guide to ensure a similar number of questions on both questionnaires concerned rules of the game, important tennis events, terminology, and principles of the game. Two tennis instructors (pros) at the Tennis Club plus several acquaintances who have played tennis in organized associations for many years agreed on the appropriateness of the questions to assess tennis knowledge. Other materials included a taperecorder.

Procedure

The procedure was identical with that described earlier, with the exception that the subjects were tested individually in a quite place at the Tennis Club. They were asked to tell a story about tennis rather than soccer, that was scored using the scoring system designed for use in Experiment IA.

Design and Analysis

Overall knowledge of Story Structure was investigated with a stepwise multiple regression analysis with Story Structure (production scores from 2 to 6) as the dependent variable, and Age, Expertise, and Story Content as the independent variables. Only story categories 2 to 6 were included as no children generated stories rated as Scripts (rating 1) or Goal-based Stories with multiple episodes (rating 7). Similar to Experiment IA, Age and Expertise were both continuous variables. Age in months ranged from 83 to 159 (6.11 to 13.3 years), and Expertise ranged from 29 to 83 percent. Story Content was again measured as a score of 1 to 4. Additional analyses conducted were the same as those reported in Experiment IA.

Results and Discussion

Regression with Story Structure

Table 6 displays the results of the regression analysis. R for the final regression equation was significantly different from zero, $F(1, 27) = 20.40$, $p<.001$. Age was the only variable that contributed significantly to the regression of Story Structure, with a t value of 4.52, and $R^2 = .43$. The variable Expertise approached significance (t-value = 2.01, $p=.052$).

Mean Age and Expertise for Story Structure

An additional analysis (Tukey-HSD procedure) was conducted on the mean differences for Age and Expertise for each type of Story Structure. For the Story Structures 2 through 6, the mean ages were 101 months (8.5 years), 114 months (9.6 years), 145 months (12.1 years), 139 months (11.7 years), and 140 months (11.8 years), respectively. The mean expertise levels in percent (standard deviations in brackets) for the Story Structures 2 through 6 were 37 (0), 48.2 (13.7), 59 (0), 63.8 (9.8), and 63.1 (9.0), respectively. For Age, there were significant differences ($p<.05$) between Story Structures 2 vs. 5,6; and 3 vs. 5,6. For Expertise, there were significant differences ($p<.05$)

Table 6. Multiple Regression with Age, Expertise, and Content Variables on Knowledge of Story Structure for Tennis

Variables	Structure(DV) B[a]	b[aa]
Age	.0470**	.66
Expertise	.3508	
Content	.2376	
	Intercept=-1.69	

Multiple R = .66
R^2 = .43
Adjusted R^2 = .41

Correlations

	Structure (DV)	Age	Expertise	Content
Structure	1.00	.66	.62	.42
Age	.66	1.00	.60	.32
Expertise	.62	.60	1.00	.28
Content	.42	.32	.28	1.00

Means and Standard Deviations

	Structure(DV)	Age	Expertise	Content
Mean	4.7	132	58.2	2.2
SD	1.4	18.9	12.8	.89

[a] B - unstandardized regression coefficients
[aa] b - standardized regression coefficients
** P<.001

between Story Structures 2 vs. 5,6.

Consistent with Experiment IA, this analysis showed that there is a natural division between Story Structures for Age (age approximately 9.0 years = Descriptive/Reactive Sequences vs. age approximately 11.8 years = Goal-based Stories). There is also a division between Story Structures for low expertise (43%) and high expertise (63%) for Descriptive/Reactive Sequences vs. Goal-based Stories, respectively.

Number of Passages by Story Structure

Similar to Experiment IA, there were no passages generated as Scripts or Goal-based Stories with multiple episodes, and very few passages generated as Nongoal-based Stories (1/29). See Table 7 for the number of passages generated from each category.

Regression with Story Content

A second stepwise regression analysis with Story Content as the predicted variable was conducted to investigate the relationship between story structure and content. This analysis showed that Storytype marginally contributed to the prediction of Story Content ($\underline{F}(1, 27) = 5.94$, $\underline{p}=.02$, $\underline{R}^2 = .18$, adjusted $\underline{R}^2 = .15$).

Supplementary Analysis

An additional analysis was conducted on the number

Table 7. Total Number of Passages Generated for Each Type of Story Structure for Tennis (Percentages are in Brackets).

1	Scripts	0	(0%)
2	Descriptive Sequences	2	(7%)
3	Reactive Sequences	6	(21%)
4	Nongoal-based Stories	1	(3%)
5	Abbreviated Episodes	9	(31%)
6	Goal-based Stories	11	(38%)
7	Goal-based Stories with multiple episodes	0	(0%)
	Total	29	(100%)

of story categories such as setting, initiating event, attempt, consequence, ending etc. for Age. Similar to Experiment IA, the proportion of settings, initiating events, attempts, consequences, and reactions was calculated for those stories classified as an Abbreviated Episode, Goal-based Story, or Goal-based Story with multiple episodes. Because of the small number of subjects in some age groups, only the proportions were calculated. Consistent with Experiment IA, a Kruskal-Wallis analysis indicated that there were no significant age differences in the proportions of categories generated in each story ($p > .05$).

Summary of Experiment IB Results

Overall, the findings of this experiment indicated that there are age-related differences in the structure of tennis knowledge, similar to the previous findings with soccer knowledge. The expertise-related differences in story structure approached significance. In a second area of expertise, the trend is for children with less expertise to generate poorly structured stories compared to children with more expertise. Specifically, younger children and those with less expertise primarily generate stories with some story categories but with no clear goal structure.

Alternatively, older children and those with more expertise primarily generate Goal-based Stories with all necessary story categories and a clear goal structure. Again, these findings for age are consistent with previous research (e.g., Fitzgerald et al., 1985; Olson & Gee, 1988; Stein, 1979; Stein & Policastro, 1984).

The main conclusion from Experiments IA and IB is that developmental differences in the structure of knowledge are not minimized for experts in a particular domain. It seems apparent that level of expertise must also be considered if one is interested in studying the relationship between knowledge and cognitive functioning such as memory processing. There may be memory processing differences between children with different expertise levels on materials that reflect differences in knowledge representation. Similar to previous research indicating that knowledge base differences may be confounded with age (e.g., Bjorklund, 1987; Bjorklund et al., 1983), knowledge base differences may also be confounded with expertise level. The relationship between knowledge representations and memory processing was addressed in Experiment II.

CHAPTER III

EXPERIMENT II: KNOWLEDGE BASE AND MEMORY

The purpose of this experiment was to investigate the influence of knowledge on acquisition and long-term retention performance in younger and older children who have more or less expertise in soccer. Based on the findings of Experiments IA and IB it is clear however, that differences exist in the structure of knowledge for younger versus older and particularly low expert versus high expert children. In the present experiment, the influence of these differences in knowledge representation of experts (e.g., more or less integrated and elaborated) on memory functioning was investigated. Developmental studies of memory processing have not considered the possibility of differences in the structure of knowledge for experts of different ages that may influence memory processing. More specifically, the purpose of this experiment was to begin to dissever the contribution of age and knowledge base factors to long-term retention. I was especially interested in findings that 'bring out' the respective contributions of age and knowledge base factors to forgetting and hypermnesia. The approach used was to measure retention performance for children who varied in level of expertise, but who were the same age. Similarly, the effects of age on retention performance, were measured with children who differed in age, but who were at the same level of expertise.

Method

Subjects

The age groups used in this experiment correspond to the divisions for Story Structure observed in Experiments IA and IB, and elsewhere (e.g., Fitzgerald et al., 1985; Salatas Waters & Hou, 1987), namely, younger children (approximately 9 years) and older children (approximately 11 years). Younger children's stories were primarily Descriptive and/or Reactive Sequences, whereas older children's stories were primarily Goal-based Stories. In addition, previous research with expert children have used similar age divisions (e.g., Korkel & Schneider, 1989; Means & Voss, 1985; Schneider, Korkel, & Weinert, 1989). Specifically, the subjects in this study were male soccer players registered in the St. John·s Minor Soccer Association League. There were 44 younger children ($\underline{M}$ = 8.8 years, $\underline{SD}$ = 9.8, Range 6.10 to 9.11 years) and 49 older children ($\underline{M}$ = 11.5 years, $\underline{SD}$ = 6.6, Range 10.0 to 12.7 years). All children were volunteers and were obtained via written parental consent.

Materials

Stimulus materials consisted of the same 37-item questionnaire used in Experiment IA that assessed children's current knowledge about soccer (refer to Experiment IA for details of the questionnaire). In addition, subjects memorized soccer stories. There were two types of stories - poorly structured and well structured stories. Both stories were constructed by first choosing stories from those generated in Experiment IA, one from each of the story structure categories 2 and 6 was selected (to represent a poor and well structured story, respectively). The stories were modified so they had a similar word count. The poorly structured story was 179 words in length, the well structured story was 192 words in length. The stories were designed to be equally familiar to all children by ensuring they were consistent with information likely to arise in this sport. Also, proper names (team and person names) were changed so they differed from names used by the soccer league. Each story consisted of 18 propositions. The stories are presented in Appendix D.

Procedure

Subjects were tested individually in a quiet room in their home. Each subject initially answered the pretest questions on soccer in the same manner as Experiment IA. The score on this questionnaire was converted into a percentage correct, and reflects level of expertise for soccer knowledge. For this experiment subjects were assigned to either a High Expertise or a Low Expertise group based on their score on the soccer questionnaire. Subjects who scored above 65% were classified as children with high expertise in soccer, subjects with scores less than 65% were classified as children with low expertise in soccer. The mean expertise level was 76% for the high expert group, and 50% for the low expert group. These means are similar to the mean differences found in Experiment IA between poor and well structured stories for Expertise (expertise 57% = Descriptive/Reactive Sequences vs. expertise 76% = Goal-based Stories). In addition, the classification of low expert children used here is similar to the classifications used for research using the novice-expert paradigm (e.g., Schneider et al., 1989). However, the current criterion for high expertise is more strict than those used previously.

After completion of the pretest, subjects participated in two memory sessions, an acquisition session and a long-term retention session, spaced 4 weeks apart. During acquisition, each subject memorized one of the stories under free recall procedures. To control for developmental differences in reading ability, the experimenter read the story aloud the first time, and subsequently as required. After the story was read once completely, children performed 30 seconds of buffer activity, which consisted of engaging the child in conversation unrelated to soccer. The child was then given a free recall trial where he was asked to recall as much of the story as possible in any order. The experimenter told the child that it was sufficient to recall the gist of the story rather than remembering it word-for-word. Recall continued until the complete story had been recalled or until 20 seconds had elapsed without a response. At this time the experimenter asked if there was anything else he could remember. These study-buffer-recall cycles continued until subjects recalled all 18 propositions from the story on two consecutive trials. This session lasted approximately 50 to 60 minutes.

Although subjects recalled via gist, their stories were scored on the 18 propositions of the stories (e.g., Howe, 1991). Children's propositional recall was scored using procedures identical with those typically found in the literature (e.g., Howe, 1991; Johnson & Mandler, 1980; Mandler & Johnson, 1977; Stein & Glenn, 1979). Specifically, children's responses were scored for the number of propositions correctly recalled. A response was considered correct if the subject recalled the main idea of the proposition using either originally presented wording or semantically similar wording.

Four weeks later each child participated in a long-term retention session. Children were instructed to remember everything they could from the story presented one month previously. The children were given a sequence of four recall-buffer cycles for the previously memorized story without further study trials. In other words, children were not shown the story again, but were asked to recall everything they could from the story they learned previously. This was followed by 30 seconds of buffer activity which involved engaging the child in conversation unrelated to soccer. This procedure continued until four recall trials had been administered. The children's responses were scored the same as described above for the acquisition session. This session lasted approximately 15 to 20 minutes.

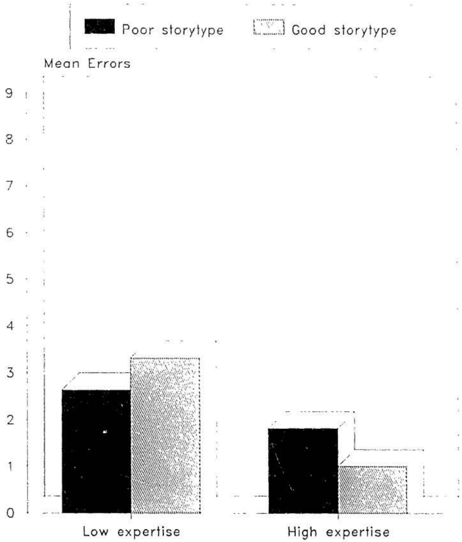
Results and Discussion

The design of this experiment was a 2 (Age = younger versus older children) X 2 (Expertise = low versus high expertise) X 2 (Storytype = poor versus well structured) X 10 (Trials: acquisition) OR 4 (Trials: long-term retention) factorial where the first three factors were between subjects and trials was within subjects. The acquisition analysis was based on the maximal trial of the last error for the child who took the longest to reach criterion, which was 10 trials. The results are reported first for the acquisition session and second for the long-term retention session. For acquisition, an analysis of variance (ANOVA) on the errors (propositions not recalled) in recall was performed. The purpose of using ANOVA in this experiment was to ensure consistency with existing knowledge base research and because this was preliminary research. For retention, an analysis of covariance (ANCOVA) on the errors in recall was performed. The reason for using an ANCOVA on the long-term retention data was as an additional control for levels-of-learning differences at acquisition (e.g., Howe, Courage, & Bryant-Brown, in press). The criterion design at acquisition was important to bring subjects close to similar learning levels (because with single trial designs, many items are likely to be unlearned). However, there may still be differences in learning at the end of acquisition. A covariate was used (total errors at acquisition) to statistically control these effects at long-term retention.

Acquisition

For acquisition performance, the ANOVA produced significant main effects for Age, $F(1, 850) = 58.37$, $p<.001$; Expertise, $F(1, 850) = 41.42$, $p<.001$; and Trials, $F(9, 850) = 84.70$, $p<.001$. Not surprisingly, younger subjects had more errors overall than older subjects ($M = 3.10$, $M = 1.41$, respectively), low expert subjects produced more errors ($M = 2.94$) than high expert subjects ($M = 1.40$), and errors decreased over trials to criterion.

More importantly, there were several significant 2-way interactions. First, as seen in Figure 1, an Expertise X



<u>Figure 1</u>. Mean Errors at Acquisition for High and Low Experts as a Function of Storytype.

Storytype interaction emerged, $F(1, 850) = 22.32$, $p<.001$, indicating that, as predicted, low experts had more errors with the good storytype than the poor storytype, and high experts had more errors with the poor storytype than the good storytype. Newman-Keuls tests confirmed that these differences in memory for storytypes were significant differences for low expert ($p<.01$) and high expert ($p<.01$) children. Consistent with other knowledge base research, these findings suggest that memory performance is better when children are tested with materials consistent with their current level of knowledge.

Second, as seen in Figure 2, the Age X Expertise interaction ($F(1, 850) = 9.90$, $p=.002$) showed that for both ages, low experts had more errors than high experts, but younger subjects had more errors, regardless of expertise. Younger low experts had the most errors, older high experts the least, and the younger high experts were comparable in errors to the older low experts ($p>.05$). For younger children, the difference between low and high experts was significant ($p<.01$). In addition, further Newman-Keuls tests revealed that for the low expert group, there was a significant difference between younger and older children ($p<.01$), but for the high expert group, these age differences disappear ($p>.01$). These findings provided evidence that expertise and age facilitate memory

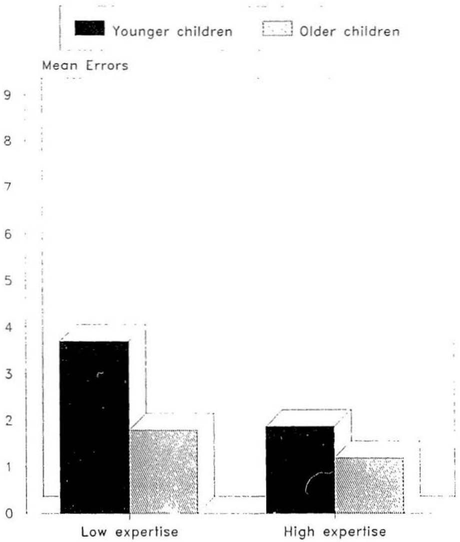


Figure 2. Mean Errors at Acquisition for High and Low Experts as a Function of Age.

performance at acquisition. Although acquisition performance is facilitated with more elaborated knowledge for both ages, younger children appear to benefit more from having elaborated knowledge. In other words, a more complex explanation is required to account for the relationship between prior knowledge and memory performance. Age differences in knowledge are minimized only for children high in expertise. This indicates that greater attention should be given to differences in expertise levels, especially for younger children when studying memory acquisition processes.

There were 2 additional significant 2-way interactions with Age. The Age X Trials interaction ($F(9, 850) = 4.70$, $p<.001$) revealed that older children learned the stories at a faster rate than the younger subjects, an expected finding (e.g., Howe & Brainerd, 1989). The interaction between Age and Storytype ($F(1, 850) = 10.05$, $p=.002$) indicated that there were significant differences between the younger and older children for both the poor storytype ($p<.01$), and a smaller difference for the good storytype ($p<.01$) (see Figure 3).

Finally, there was an Expertise X Storytype X Trials interaction, $F(9, 850) = 3.55$, $p<.001$. Figure 4 shows that children low in expertise learned the poorly structured story faster than the well structured story, and children

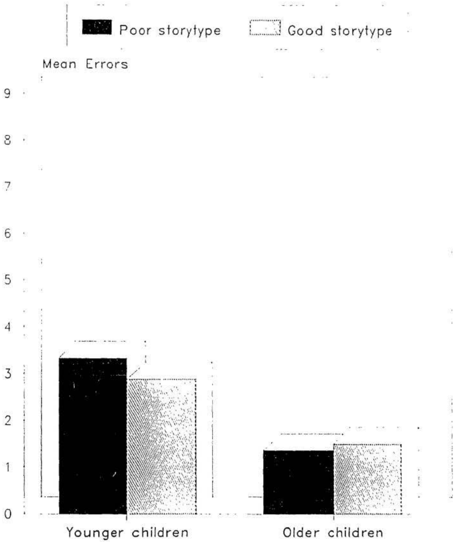
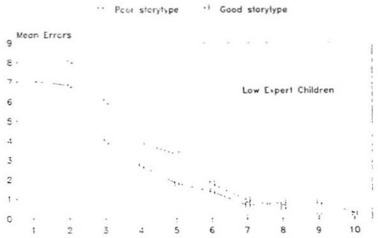


Figure 3. Mean Errors at Acquisition for Younger and Older Children as a Function of Storytype.



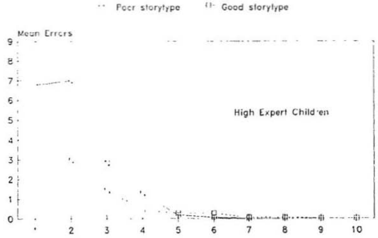


Figure 4. Mean Errors at Acquisition for High and Low Experts as Function of Storytype for Trials.

high in expertise learned the well structured story faster than the poorly structured story. This suggests that stories that are consistent with knowledge base are learned with fewer errors overall, and more quickly. This provides support for the suggestion that when investigating memory functioning in expert children, researchers should use materials that are consistent with expertise level.

The 3-way interaction qualifies the 2-way interactions in that they are modified by where in the acquisition curve one looks. That is, there were age and expertise differences early, but not later in acquisition. This is of course, the hazard of using traditional single-trial designs. This points out the importance of using multiple trial designs (criterion designs preferably) as a procedural control to ensure materials are equally learned by all subjects. In addition, further support for multiple trial studies come from the finding that these interaction effects disappear if the acquisition data is analyzed collapsed across trials.

Retention

For the long-term retention analysis, the covariate was nonsignificant. The retention analysis showed that, similar to acquisition performance, there were main effects for Age, $\underline{F}(1, 339) = 9.23$, $\underline{p}<.01$; Expertise, $\underline{F}(1, 339) = 7.62$, $\underline{p}<.01$; and Trials, $\underline{F}(3, 339) = 6.94$, $\underline{p}<.001$. These findings revealed that younger subjects forgot more than older subjects (M = 10.1, M = 8.64, respectively), children with low expertise forgot more than those with high expertise (M = 9.94, M = 8.63, respectively), and errors decreased across trials (M = 10.7, 9.6, 8.7, 8.2 for Trials 1 to 4, respectively). This provides evidence that there are age- and expertise-related trends in long-term retention. Unlike much of the early forgetting research, these results show that forgetting is not constant across age. In addition, the findings that errors decreased across trials suggests that hypermnesia occurred. However, there were no interactions with Trials, indicating that hypermnesia remains constant across age and expertise.

The present findings are consistent with recent long-term retention studies that provided evidence that forgetting does vary developmentally (e.g., Brainerd et al., 1985; Howe, 1987, 1991; Howe et al., 1992), and for expertise (e.g., Clark & Howe, 1990). Consistent with the most recent hypermnesia findings (e.g., Howe et al., 1992), this study shows that hypermnesia is less important than forgetting in accounting for developmental changes in long-term retention performance.

There were no significant higher order interactions in this analysis. The critical Expertise X Storytype interaction, evident at acquisition, did not emerge at long-term retention. This indicates that better retention is not dependent on recalling information consistent with current level of knowledge base development. Although memory acquisition is better when tested when materials consistent with current level of knowledge (e.g., low experts perform better with poor storytype, high experts perform better with good storytype), memory retention simply depends on one's level of expertise (high versus low).

The results of the retention analysis indicated that at a global level long-term retention does vary with age and expertise level. Specifically, forgetting was minimized with more knowledge, and for older versus younger children. Although hypermnesia was evident, there were no developmental or expertise differences in hypermnesia. In addition, no specific effects emerged with the type of materials memorized in facilitating the retention of information over a 4-week interval. Alternatively, the knowledge base does facilitate the acquisition of information for experts, particularly when tested with materials consistent with the representation of knowledge in the knowledge base.

To summarize, the findings of Experiment II suggest that knowledge does not influence acquisition and retention processes similarly. It appears that the influence of knowledge on memory performance is greater for the initial acquisition of information than the long-term retention of information. In terms of long-term retention processes specifically, the knowledge base effects vary as a function of whether forgetting or hypermnesia is measured. Specifically, forgetting, but not hypermnesia, varies across age and expertise. Finally, acquisition, but not retention performance is better when tested with materials consistent with current level of domain-specific knowledge.

CHAPTER IV

CONCLUSIONS AND GENERAL DISCUSSION

A. Research Objectives

The first purpose of this dissertation was to examine the structure of knowledge in children with varying levels of expertise in a specific domain. The second and more prominent purpose was to examine the influence of knowledge on children's long-term retention performance. The first objective was achieved through Experiments IA and IB where children were asked to generate a story in the domain of either soccer or tennis. Experiment IA also provided stimulus materials for Experiment II, which was an investigation of the relationship between changes in knowledge structure and memory processes. In this study, children with either high or low soccer expertise memorized one of two domain-related stories, then recalled the story after a 4-week retention interval.

It is already well established that there are robust effects of knowledge on the initial acquisition of information. Few researchers have addressed the development of long-term retention itself, let alone directly studying whether the knowledge base has lasting effects on the retention of information over long periods of time. As discussed previously, there is now evidence that early reports of few developmental changes in retention were likely misleading because of levels-of-learning confounds and inconsistencies in definitions. In addition, the few studies of the relationship between knowledge base and long-term retention have produced different results. For example, Chi and Koeske (1983) reported that domain-specific knowledge did enhance long-term retention for a child knowledgable about dinosaurs. Clark and Howe (1990) reported that knowledge did influence long-term retention, but differently than at acquisition. Forgetting was less for experts compared to novices, whereas reminiscence did not vary with expertise. A second objective of this research was to examine the influence of knowledge base factors (i.e., structure of domain-specific information) to memory performance, particularly long-term retention. The levels-of-learning confound was eliminated by ensuring all subjects reached a strict learning criterion at acquisition. The findings of Experiment II are discussed first, followed by Experiments IA and IB because the memory study was the main focus of this dissertation research.

B. Major Findings and Discussion

Knowledge Base and Memory

The main findings of this research indicated that the effects of knowledge on memory performance were prevalent at acquisition and long-term retention, although the effects were stronger at acquisition. The global findings for the acquisition phase of Experiment II confirmed the hypothesis that the knowledge base is an important factor in facilitating memory performance, although this depended upon the relationship between age and expertise. Age differences in knowledge were minimized only for children high in expertise. For children low in expertise, older children outperformed younger children. In fact, a score of approximately 70% on a measure of expertise (e.g., questionnaire) was required for age differences to be minimized. The use of a higher criterion of expertise (i.e., 70% on some external measure) may be necessary to ensure subjects have a similarly elaborated knowledge base, so age confounds with level of expertise are minimized.

The finding that acquisition performance was better when children were tested with materials consistent with knowledge base development is similar to previous knowledge base research for a variety of stimulus materials and ages (e.g., Bjorklund, 1987; Bjorklund & Thompson, 1983; Bjorklund et al., 1983; Bjorklund & Zeman, 1983; Chi, 1978; Chi & Koeske, 1983; Clark & Howe, 1990; Knopf et al., 1988; Korkel & Schneider, 1989; Kuhara-Kojima & Hatano, 1991; Schneider & Korkel, 1989; Schneider et al., 1989, 1990). In the present research, children with different levels of expertise learned a passage with fewer errors when it was consistent with their level of knowledge base elaboration (low experts had fewer errors with the poorly structured story, high experts had fewer errors with the well structured story). Bjorklund et al. (1983) have argued that using adult-defined word lists results in a confound between differences in information processing and age differences in knowledge base. Similarly, the present results suggested that if expertise-related differences in knowledge representation are not considered, a confound may result between differences in information processing and expertise differences in knowledge representation. For example, if using high expert materials with low expert subjects, information processing differences may be due to knowledge base differences. If knowledge-base consistent materials are used, information processing differences between experts would more likely be a reflection of true differences, and not due to differences in knowledge base.

More important, the findings of the long-term retention session showed that there were developmental- and expertise-related trends in long-term retention. Here, both age and expertise played an important role in preventing the demise of memory traces over time. Older children and children high in expertise showed less forgetting than younger children and those low in expertise. Having tightly integrated knowledge at acquisition helped to decrease forgetting but not increase hypermnesia. Hypermnesia effects generally have been found to be smaller than forgetting effects and not vary as a function of age (e.g., Clark & Howe, 1990; Howe et al., 1992). This study also produced few developmental findings for hypermnesia. Children's recall did improve as a function of test trials, but this did not vary as a function of age or expertise. Taken together, the recent long-term retention literature indicates that developmental trends in retention performance are best explained by age changes in forgetting, but not hypermnesia performance (e.g., Brainerd et al., 1990).

Further, the important Expertise X Storytype interaction did not emerge at long-term retention, indicating that retention was not facilitated when tested with materials consistent with level of expertise (i.e., low experts showing better retention with the poorly structured story, high experts showing better retention with the well structured story). Children learned the story consistent with their level of knowledge elaboration fastest at acquisition, but no differences emerged at retention. Similar findings have been reported by Yussen et al. (1991) who studied memory learning and forgetting with adults for stories of good versus poor form. They found that after a 24-hour and 1-week retention interval, good story form facilitated learning the stories, but did not influence retention. In the present study, knowledge base consistent materials resulted in large and robust advantages in memorizing stories, but for retention of stories over a 4-week interval, expertise was the primary mediator in facilitating retention.

With appropriate methodological controls in place (e.g., levels-of-learning controls), the differences observed in retention for children with more and less knowledge in an area suggested that the knowledge base does influence retention, but in different ways than acquisition. This is consistent with recent evidence that indicates long-term retention contributes to developmental differences in memory performance and is influenced in different ways by factors associated with acquisition. This has been reported for a variety of ages, stimulus materials and retention intervals (e.g., Brainerd et al., 1985; Brainerd et al., 1990; Clark & Howe, 1990; Howe, 1987, 1991; Howe et al., 1992). For example, the findings of this research corroborate the Clark and Howe (1990) study, where fewer differences were found in forgetting than acquisition between expert and novice children.

To summarize, this research was aimed at investigating the independent contributions of age and knowledge base factors to both memory acquisition and long-term retention performance. The findings indicated that at acquisition, there was an interaction between age and expertise, but at long-term retention, it appeared that age and expertise independently contributed to performance because of the absence of this interaction. However, for both acquisition and long-term retention, differences were not entirely eliminated after partialling out expertise or age. Overall, evidence is mounting that knowledge influences acquisition and retention processes differently (e.g., Brainerd et al., 1985; Clark & Howe, 1990; Howe, 1987). Few investigators have looked at asymmetries between acquisition and long-term retention processes. However, this research indicated that long-term retention is an important part of explicating a comprehensive understanding of memory development, but differs in notable ways from acquisition processes. Specifically, according to the findings of this research, enhanced memory performance due to knowledge showed large effects at acquisition compared to retention. The present results also suggested that with a 4-week retention interval, only the forgetting aspect of global retention performance and not hypermnesia, varied as a function of expertise.

How should one explain these long-term retention findings? There is evidence from constructive aspects of memory that what one already knows will influence how one encodes and remembers an event (e.g., Bartlett, 1932; in Bjorklund, 1987; Paris, 1978; Piaget & Inhelder, 1973). Also, DeMarie-Dreblow (1991) has suggested that having the knowledge may only be a first step in improving memory, as seen here by less forgetting for high versus low experts. Some other factor may be necessary for this knowledge to be accessed and used. She has suggested that several factors, one of which is the structure of knowledge, likely contribute to enhanced memory performance, in addition to having more knowledge per se (DeMarie-Dreblow, 1991). Perhaps low experts "restructure" the good structured story so it is more similar to their knowledge base representation, resulting in no differences in retention for the two types of stories. Children with high expertise may engage in a similar process (e.g., filling in missing story parts), so again retention of the two storytypes is equivalent. In other words, each group of children could use their existing knowledge representation to process both the stories efficiently. Overall, having more knowledge in an area facilitated retention, but this should be considered with respect to the structure of existing knowledge. Specifically, to-be-learned information may be restructured to reflect the current knowledge representation to make it as memorable as knowledge-representation consistent information.

Story Structure and Knowledge Base

The findings of Experiments IA and IB provided a greater understanding of how knowledge differs for age and expertise. The analysis of the structure of domain-specific knowledge suggested that differences in structure are one important source of knowledge development. This study revealed that experts of different ages, and with varying levels of expertise do not have similarly structured knowledge. There were age- and expertise-related increases in the elaboration of knowledge, as reflected in producing more prototypical stories. Thus, expertise in itself was not sufficient to minimize differences in knowledge structure across age. These results are consistent with Gobbo and Chi (1986) who found that expert knowledge is more structured (e.g., integrated and cohesive) than novice knowledge. They reported that compared to novices, expert's production protocols were more connected syntactically. In other words, the experts protocols included more "because" and "if" connectors, and took the form of a more coherent discourse.

These findings are also consistent with the results of research studies that directly addressed the development of story structure in children's story productions (e.g., Fitzgerald et al., 1985; Olson & Gee, 1988; Salatas Waters & Hou, 1987; Stein, 1984; Stein & Glenn, 1979; Stein &

Policastro, 1984). For example, both Fitzgerald et al. (1985) and Salatas Waters and Hou (1987) used a production task and scoring system similar to the present research that differentiated passages with no or few causal/temporal connections from those with temporal/causal connections and the inclusion of story categories (episodic structure). These researchers found that the passages younger children (approximately 8 years of age) generated were significantly different from those generated by older children (approximately 11 years of age). Specifically, younger children generated descriptive/reactive passages characterized by no clear goal, and an inconsistent use of temporal/causal connections. Older children generated passages with a clear goal, characterized by more causal connections and the inclusion of some story categories. It is clear from this literature that children's knowledge of what constitutes a better structured or more prototypical story increases with age. Thus, there were differences in the complexity of story structure with increasing age. However, the present research indicates that for domain-related knowledge, expertise is more highly related to story structure than age.

C. Contributions to Existing Research

This dissertation research is related to the general concerns of knowledge base and children's memory development in several notable ways. One issue is to unequivocally establish the existence of developmental trends in long-term retention performance, and to determine if this is different from the processes occurring at acquisition. The importance of long-term retention comes from everyday cognition and studies of children's testimony and classroom learning (e.g., Brainerd et al., 1990; Howe & Brainerd, 1989), where successful retrieval of information after a retention interval is demanded. Another issue is determining the precise relationship between knowledge and developmental changes in memory performance. Recently, this has revolved around studying the content and structure of knowledge. For example, the existing knowledge of experts enables them to process domain-related information more efficiently, presumably because as expertise is attained, knowledge is updated and restructured (e.g., Chi, Hutchinson, & Robin, 1989). Further, changes in the content and structure of knowledge are thought to be related to changes in strategy use and are often considered an important source of these changes (e.g., Howe & O'Sullivan, 1990; Schneider et al., 1990). To provide a comprehensive understanding of the relationship between developmental changes in knowledge and strategy use, as well as other types of cognitive processing such as comprehension and inferencing, research efforts need to focus on several factors. These include measuring how knowledge is structured, how it changes with age and expertise, and how different types of knowledge interact (e.g., Chi & Ceci, 1987; Howe & O'Sullivan, 1990; Schneider et al., 1990).

This dissertation research adds to these general issues first, in providing further support to establish the importance of long-term retention to memory development, separate from acquisition performance. In addition to the observed developmental trends in retention,differences in the amount and structure of knowledge (e.g., expertise) reduced forgetting over a 4-week retention interval. Recovery of information (hypermnesia) on a subsequent occasion was also observed, but was found to be developmentally constant. Second, evidence was obtained to indicate that differences in the structure of knowledge occurred when more knowledge is attained in an area (e.g., children become experts). However, age-dependent differences in the structure of domain-specific knowledge remained even for children classified as experts. Finally, the importance of knowledge to memory acquisition was corroborated by this research, and memory development research in general was extended by the findings that knowledge is important to long-term retention, but in different ways than acquisition.

D. Summary

There are two main conclusions from this dissertation research. First, knowledge is important to the initial acquisition and long-term retention of domain-related information, but in different ways. Memory acquisition is facilitated by an elaborated knowledge base, but this depends on the relationship between age and expertise. Long-term retention is also related to knowledge, but this relationship is less robust than at acquisition, and depends on which aspect of retention is measured. Expertise- and age-related trends occur in forgetting, whereas hypermnesia does not vary as a function of expertise or age. Thus, knowledge influences acquisition and retention processes differently. At acquisition, age and expertise factors interact in a complex manner, but at long-term retention, age and expertise factors independently contribute to performance. Second, age-related differences in the structure of knowledge do not disappear once a child is classified as an "expert" in a particular domain. A child's level of expertise is an important factor in determining the nature of the structure of knowledge. Further research into knowledge structure differences among children with expertise is warranted, to extend and generalize these findings to other domains. In terms of advancing our understanding of memory development, investigators should,

1) ensure multiple-trial designs are used at acquisition for investigating long-term retention processes, and 2) determine more precisely the relationship between knowledge and long-term retention including the configuration of forgetting and reminiscence processes. A beginning in this matter has been achieved through this dissertation. Future research should focus on additional domains of knowledge, and different retention intervals to determine the generalizability of these memory findings. Research aimed at what happens to memory traces over time would also prove helpful in learning more about the different effects of knowledge at acquisition and long-term retention.

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APPENDIX A: Soccer Pretest

1. The purpose of the game of soccer is to:
   a) take the ball from the other team
   b) run with the ball to the goal keeper
   c) score goals and keep the other team from scoring
   d) play the game until both halves are over

2. How many shifts are there in soccer? How long?

   ____

   How long is each half in soccer? ____________________

3. How many players from each team play each game?

   ____

4. Which player is most likely to score goals?
   a) goal keeper b) defender
   c) forward d) runner

5. What does it mean to say a player "cleared the ball"?
   a) he made a long pass
   b) it went over a player's head
   c) he passed to a teammate
   d) he kicked it out of bounds

6. When a player makes a cross, this means?
   a) he runs to the other side of the field
   b) he passes the ball to the other side or to the centre of the field
   c) he runs in front of the opponent
   d) he kicks the ball to the end of the field

7. A throw-in occurs when?

   a) the ball has passed over the touchline

   b) the ball has passed over the defending teams' goal line

   c) the ball is thrown into the goal

   d) a team throws-in the towel

8. Which team has the kick-off to start the match?

   a) the team that won the coin toss

   b) the home team (that is, the team on whose pitch the match is being played)

   c) the away team

   d) the team that the referee picks

9. What is dribbling?

   a) use of the feet to move the ball along the ground

   b) bouncing the ball down the field

   c) passing the ball back and forth with teammates

   d) a deceptive move to fool an opponent

10. Which players are not part of the soccer team?

   a) forwards and wingers

   b) defenders and wingers

   c) runners and headers

   d) midfielders and defenders

11. Some soccer players are called amateurs. This means?

a) they play soccer for fun

b) they play centre field

c) they are defeated by farm teams

d) they are paid to play soccer

12. When a player has trapped the ball, what has he done?

a) scored a goal

b) stopped the ball under his body

c) stopped the ball and brought it under control?

d) deflected the ball

13. When a team has a shut-out game, this means?

a) neither team scored any goals

b) one team had no goals scored against them

c) their were no penalties called

d) both a and c

14. Players who are not currently on the field are said to be? ____________________________

15. When is a penalty kick awarded?

a) when a player grumbles

b) when the goal-keeper leaves the goal area

c) when an opposing player receives a bad foul in the penalty area

d) when a player commits a foul for the second time

16. The technique of "heading" means?

a) a player is moving towards the goal line

b) the ball is above the players head

c) hitting the ball with the head

d) moving the ball down the field

17. If the goalkeeper saves the ball, he has?

a) deflected and/or caught the ball

b) taken the ball home for the next game

c) taken the ball from the opponent

d) prevented the ball from going out of bounds

18. What/where is the centre circle?

____

19. What does the linesman do?

a) makes sure the playing field has lines

b) coaches the team during play

c) enforces the rules of the game

d) indicates when the ball is out of bounds

20. What is the primary manoeuvre/technique in soccer?

a) passing b) kicking

c) shooting d) tackling

21. Which of the following would a goal-keeper not be responsible for?

a) catching and punting

b) passing and dribbling

c) throwing and rolling

d) catching and rolling

22. Who is the person that enforces the rules of the game?

a) referee b) linesman c) goalkeeper

d) captain

23. What options does a player have after receiving and bringing the ball under control?

a) passing and shooting

b) passing and dribbling

c) shooting

d) passing, shooting, and dribbling

24. Feinting refers to?

a) lofting a pass

b) deceiving an opponent by a certain move

c) guarding an opponent

d) obstructing an opponent

25. What is the touchline?

a) side boundaries of the field

b) end boundaries of the field

c) all boundaries of the field

d) the line in the middle of the field

26. What are the types of defensive strategies?

a) zone defense

b) man-for-man defense

c) zone and man-for-man defense

d) none of the above

27. After a goal has been scored, where on the playing field does the play start again?

a) at the corner flag

b) at the touchline

c) at the penalty spot

d) at the kick-off spot on the halfway line

28. What is a "striker"? (forward)

a) the player who runs into the soccer pitch first at the start of the game

b) a soccer fan who goes to all his teams' games

c) a player who is put on the field when the team goes on the offensive

d) a player who may take a free kick

29. Where does a soccer match start?

a) in the centre circle

b) on the touchline

c) at the six yard line

d) in the penalty area

30. Which of the following terms do not apply to soccer?

a) penalty kick

b) goal area

c) touchline

d) the 18 yard area

31. Who decides if a goal has or has not been scored?

a) the linesman

b) the referee

c) the goal keeper

d) the captain of the team

32. When does a goal shot in by a forward not count?

a) when the forward was offside

b) when the forward has already scored once in the match

c) when the forward stays in the goal area

d) when the goalie was outside the penalty area

33. What does the soccer expression "to take someone's legs out from under him" mean?

a) to contact a players' legs with your own legs in such a way that he falls down

b) to grab a player's legs with your hands so that he falls down

c) it's a funny expression that means the coach is taking a player off the field

d) it's an expression for a gymnastic drill, in which one player grasps another player's legs.

34. What does "setting up the ball for a player" mean in soccer?

a) a goal-keeper sends the ball to a defender

b) a forward sends the ball to a teammate so he has a chance of scoring a goal

c) placing the ball on the field at the start of the game

d) passing the ball to an opponent

35. When does the referee whistle to call an "offside"?

a) when an opponent is not at least 9 yards from the ball at a free kick

b) when all players are in one half of the soccer field

c) when a player who is alone in front of the opponents' goal receives a pass

d) when a goal-keeper runs into the other half of the playing field

36. What happens when a player is offside?

a) there is a time-out

b) the referee shows a player the yellow card

c) the referee awards an indirect free kick in the penalty area

d) the linesman raises the flag

37. Which statement about "offside" is correct?

a) only one forward can be offside

b) a goal-keeper can never be offside

c) a forward can be offside only if he is in the opponent's half of the field

d) the linesman blows a whistle when a player is offside

APPENDIX B: Example Soccer Stories Scored for Structure

Note: Names have been replaced with initials.

Note: --- indicates untranscribable words.

1) Scripts:

i) When you get a goal then you go in. Then the player kicks a ball to someone else. Then the player runs with it. Then somebody else takes it. Then they run with it. Then they pass to it somebody else. Then somebody else passes to somebody else then the other team gets a goal. Then if equal the referee blows the whistle. Then you get a goal and you're on again. Then I would play half game when he says go and then get a score. Then they get a score. Then the other team gets a score and sometimes it's a tie.

ii) The idea of playing soccer is trying to keep the ball from going inside the crease of the goalies net and to try and score on the other team. Try not to foul anybody. It's an interesting sport. It's like hockey but not as rough. You don't let --- if you see the ball coming towards you and there is no players, kick the ball away from you as fast as you can. When you get the ball you can either pass it, or shoot it, or you can just kick it out of bounds if it's too close to the net and too many people are coming after you trying to get it. Try not let them get any goals. Every time before a game you warm up by taking shots, but you have to hustle for the ball and as soon as you get the ball just shoot it as hard as you can at the net.

iii) In a soccer game there is two teams, two teams with eleven players on each team which play at the same time. In a game, the object in the game is to score as many goals as you can against the opposite team in a certain amount of time. There are two halves in a soccer game. And there is a goalie, there's a defense, there's a midfielder, there's a forward on each team. There is forwards that can cheer on people, there are penalty shots that are awarded when somebody has hazed the ball inside the 18, has been knocked over by an opposite player. A penalty shot is taken when somebody is taken down or has hazed the ball inside the 18. The indirect means you can not score unless you can make it passed where somebody can touch the ball, then you shoot. Direct means you shoot from the net and you score. At half you change around sides.

2) Descriptive Sequences:

i) One day I was going against the Squirrels, they are one team, I'm on the Donkeys. And I have a green t-shirt and they have a brown and white. My last kick went right across the field and I almost scored a goal. And our first game against the Hares I did some blocks, I did the leg block, knee block, stomach block, and the head block. And I went in when we were against the, what are they called again, when we were against the Bobcats. We won 9 to nothing and in another game against the Wildcats we won 2 to 1. I got a stomachache and when I got home my ear was bleeding from a fly bite, and my nose hurt.

ii) Someone tried to kick the ball and he fell on his back. He scored 3 goals and the other team scored 6. And when I was in goal, they shot 11 goals. I mean they shot 11 shots at me. They scored none and the defense was hardly doing anything and they scored 2. And that's was it 2 from the 11.

iii) One time when I was in soccer I got hit right in the head. It hurt and it's fun. I went across the field and then he just scored a goal by kicking it right to the other side. And the goal keeper didn't even see it and it the ball went in. And it was nice, it was good. I like soccer. I hate it when the ball hits me on the head.

3) Reactive Sequences:

i) I like soccer because I get to meet new friends from different places. And I like playing soccer. And it doesn't matter who wins or loses because the point is just for fun. It doesn't matter who wins or loses and it's just a fun game. You know, you can't always win. You can never take the ball away from the goal keeper or else you'll have your hands. I like soccer and my other friends that I know around here like soccer. My friend J., he just lives around the block. He's a really good player and so am I and a lot of other players are good too. And other people sometimes don't pass it to me but sometimes when I get the ball I try to get a goal. And once I tried to do that and I got one and after that we got a new game. That was the second last game we had. I was the first one to get the goal on that game. Soccer is fun and my other friends like soccer too. My friend James he's really good at it because he was playing soccer for 2 years. This is my second, well my first year, playing soccer. If we win two more games we might get the medal.

ii) There was about 3 minutes left and our goalkeeper D. kicked it down the field and the ball went too far ahead of me. It hit off my toe and it went out of bounds. Then after that they scored a goal and they tied the game 4-4.

iii) One day me and my friend were playing soccer. Then our friend M. came along and he wanted to join in too. So we played a little bit of soccer and then we wanted to get a drink. So we got a drink. Then after that we went to a soccer game because there was a soccer game that day. I never scored any goals but my friend M. scored a lot and also my friend B., he scored about 5 goals. And every single game so far we scored a goal. Last year we won fourth place and today we're hoping to win fourth place.

4) Nongoal-based Stories:

i) Like I was riding on my bike and I fell off and cut my knee. And when I went to the soccer field it hurt and I couldn't bend my knee, and then I couldn't run and I couldn't play. P. came over and tripped me up and I banged by knee on the grass. And then I all kinds of stuff in my knee and I couldn't run.

ii) There was this farmer with too many calves. He had to kill it and make it and he probably sold it to this big company. And they made it into a soccer ball. And then, the players started kicking it around. And I think the cow was still alive or something. I think the spirit was still in the ball and he didn't like it. He scared them all. And then they --- the ball and they played with it, they still played with it.

iii) The soccer game. Usually I play defense, so I was up for defense. So I always keep on going down. And the ball passed me down the fence, so the coach tells me to go back up. So I was right mad at him. And the ball goes right past me. And I was so mad, so I kicked the ball into the net --- the goal and it hit someone in the face.

5) Abbreviated Episodes:

i) Once I had a corner kick and my friend kicked it to me and he got the ball and he passed it to me and then I dribbled it up and then I shot. And then I nearly scored. And then my friend passed it back and then I scored. And the goalie did a drop kick and it went down to the other side of the field. And it nearly got in, but the goalie just kicked it back to the other end of the field. My friend D. dribbled it up just a little bit more and passed it to me. And I passed it back and then he scored.

ii) Last week we played a soccer game and halfway through the game my friend passed the ball to me. I took the ball up past half, he kicked it and he missed the net. The other team had a throw-in. We got the ball back and we took it off and we passed it back to a point, to the centre and he kicked it and scored. The other team took the ball. We had a kickoff. They came up and they scored on us.

iii) And the other team had the ball for the first up and they kick it up and they run up after. And one of our players kick it down the field and then down to one of the forwards. And our forwards put it to the middle where another forward picks it up and he runs down. But he's stopped by the defence which puts it back up again where one of the players get it again. But he loses it and another player gets it on the other team and he runs up. He takes a shot on the goal keeper, but the keeper saves it. And then keeper takes it and it hits somebody on the other team but it goes offside. So its our play and one of our people takes it again and it goes down the side yard where another person is waiting. And he runs in and he kicks it wide, its a goal kick. And the keeper kicks it out again. And one of our players gets it again and he goes down by the wing and he puts it in the centre. And one of the other people heads the ball and it goes in the net.

6) Goal-based Stories:

i) About a week ago I had a house league game which is in the minor Soccer Association and my team was taking on the best team in the league, the Tommies. And once the game started we have a guy on our team called B. And he usually goes offside about 7 times a game. And at the start of the game it happened and we managed to score in the first 5 minutes. And then we played the game fairly aggressively. And then our defense was playing well and our forwards were having a lot of shots but they wouldn't go in. By half we were still one up. And while then B. had about 4 offside calls and the team was getting a bit mad at him. After half we still passed up the line. We were playing our plays up the line. We were trying to cross it over and score but every time we crossed it over, B. was offside. So our coach was getting a bit mad too. So we took him off and talked to him for a bit and then our play was getting a bit better. But in the last about 5 minutes they scored a goal on us and B. came back on. And the ball got crossed over and he scored one and he wasn't offside then so it was 2 to 1 then. Then we played mainly defense for the last 5 minutes and they had a few chances. And in the last 1 minute they got a penalty shot because one of our teammates P. hands the ball inside the penalty area. And then one of their best players who was on the B Allstar team, J., who missed, he put it right off the crossbar. So eventually we won the game 2 to 1.

ii) Once upon a time, a long time ago, there was this kid and it was his first time playing soccer. He was playing two of his other friends, D. and M. And there was this other ref who didn't know how to play. So they were out playing with this brand new field, and he kicked the ball out of bounds. He didn't know what it would mean since it was his first time playing. The ref didn't know what it means because he was just beginning. So they didn't know there was going to be a throw-in. Then there was this kid who came along, J. and he knows about soccer. He told them what a throw-in was and he got the other kid to play and then he was the ref. So, they scored twice, but one goal wasn't counted because they were inside the crease. They didn't know what that means so we had to take time out and I told them about how to play soccer and after I did that they played. And then they didn't need any refs so I just went onto another soccer field and played soccer. The end.

iii) It was like already half way through the season. My best friend J. and S. one of my team members, and all them had a lot of goals this season and I didn't have one. I was like feeling sad because I didn't have a goal or anything. This whole game it was 3/4 of the way through, it was 1 to 1 and it was about 3 on 2, like where they had 3 players and we had 2. And I got out a bit far and I took a shot. There was this big guy there and like it hit off his stomach and bounced back to me. And then I shot it and I got it in the corner and it was my first goal of the season. And all my friends lifted me up by the arms and they were all cheering that and I got the winning goal of the game. I was really happy then because I got my first goal of the season.

7) Goal-based Stories with multiple episodes:

i) Well, this is my first year in soccer in the world cup league. And well the guy next to me, standing next to me is Mara Donna. Anyway I'm quite happy that I made it to the world cup game. This is the last game and hopefully we will be able to win. The game is started now, I got the ball and --- up the field, passed it Mara Donna, I passed it to Mara Donna, he's gone up the field. I go up to the corner of the net and be careful not to go offside. Mara Donna passes, he kicks it into the top right hand corner of the net. The crowd goes cracked. R. game him the rooky, he scored his first goal, his first goal of the season.

Germany, West Germany is kinda mad, they were two seconds, two minutes into the game and they got a goal scored against them. Well, Argentina might just pull this one off. They are coming up, they are trying to turn it around. You know what happened last year, West Germany won. So, Argentina is trying to win it back this year.

Oh God, the whistle blows, the first half is ended already. We're into the second half. The second half has started. So, I'm still playing, I'm still playing on the right hand side, the right striker. So, I'm going up the field again. I pass it across to the left, it goes, they kick it to Mara Donna, Mara Donna shoots. Oh, it rebounds out. I get it, I kick it across to Mara Donna, Mara Donna shoots again. He scores in the bottom right, bottom left hand corner. So the second half ends, it is 2 to 1, it is 2 to 1 for Argentina. Argentina wins the world cup. It's over, it's all over folks.

ii) The Soccer Scandal, by A. C. As from my previous story Grandfather time, which was blown up from all the clock explosion, was found by his brother who lived in South Africa and heard about the news and came to fix them up. They fixed him up and they as grandfather time went to collect more clocks to steal time. So they had this great idea as soccer was in at the summertime. So they decided to hide the clocks in the soccer balls. So, as the alarms were on the clocks, grandfather time snook into all the schools and stole all the clocks on the walls and put them in the soccer balls. As we found out the clocks were disappearing, we decided to have a quick soccer game to find out what was happening and we noticed that the ball wasn't as light as it was, so we just forgot about that and had our game.

After we decided to take our minds off of it, we decided to go to Germany. We went to Germany and saw all the players. And we saw all the balls. And there was a demonstration. Buddy, somebody was giving a demonstration on kicking and as he took his kick he just rattled the post and ball just cracked in two and a small wristwatch came out. As we finally cracked the crime, we said, we thought what happened to Grandfather time, and then we found out that Grandfather time had been stealing the clocks.

We went back and we found Grandfather time who was just, we saw Grandfather time and he was really peed off as so we blew him up last time but he got over that. So we asked him for a soccer game and he was a little reluctant. The kick-off, it was the kick-off and again as my friend from Germany was with us, I took the ball right wing, and I centred it on the trail. I took the back pass, Grandfather time was .n and took the shot and shattered his glass and caught right on the top of his ---, and as the ball went up in the air we ripped it open and found the clock. As the police were phoned up earlier were there to arrest Grandfather time and this time he was stay behind bars for a long time. Thank you.

APPENDIX C: Tennis Pretest

1. The purpose of the game of tennis is to:
   a) always win your serve
   b) collect all the tennis balls hit to you
   c) winning enough sets to win the match
   d) play games until each set is over
2. How many games does a player (usually) win in order to win the set?
   a) 7 b) 8 c) 6 d) 3
3. How long is the rest period after the third (if men) or second set (if women) in a match?
   a) 10 minutes b) 5 minutes
   c) there is no rest period d) 7 minutes
4. Who is the first server in the next set when the previous set ended with a tie-breaker?
   a) player who did not serve first in the tie-breaker game
   b) player who won the last game before the tie-breaker
   c) player who wins the coin toss
   d) player who served first in the tie-breaker game
5. What does it mean to say a player "hit the ball with top spin"?
   a) the player spins around as he/she is making the shot
   b) hitting the ball so it rotates forwards

c) hitting the ball so it goes out of bounds

d) hitting the ball so it rotates backwards

6. When a player "punches the racquet", this means?

a) throwing the racquet down because player missed a shot

b) stroke made when a player volleys the ball

c) stroke made when player smashes the ball

d) player moves hands up on the grip

7. What is the difference in the serving position in singles and doubles play?

a) there is no differences

b) in doubles, the server is further back from the baseline

c) in doubles, the server is closer to the doubles alley

d) both b and c

8. How is it decided who serves first in the match?

a) coin toss b) player on the court first

c) racquet spin d) either a or c

9. What is "ball sense"?

a) knowing what a tennis ball is

b) a good idea of what a ball may do

c) ability to hit the ball well

d) alert and ready to receive a serve

10. Some tennis players and called amateurs. This

means?

a) they play tennis for fun

b) they play down the line

c) they are paid to play tennis

d) they play with their left hand

11. In playing a groundstroke, a players' weight should be transferred from?

a) front to back   b) no weight transfer

c) legs to arms   d) back to front

12. What is the total number of games played in a set which ends with a tie-breaker?

a) 12   b) 13

c) 14   d) 6

13. Where is the baseline?

a) back of the court

b) back line of the serving box

c) side of the court

d) there is no baseline in tennis

14. Which grip is recommended for the forehand?

a) Continental   b) two-handed

c) Western   d) Eastern

15. If a player "hits an overhead", he/she has?

a) hit the ball while it is over their head

b) made a mistake

c) put the ball out of bounds

d) lobbed the ball over the other players' head

16. What is the duty of the linesman?

a) makes sure the court has lines

b) call balls out

c) enforces the rules of the game

d) coaches the players during play

17. Which of the following is NOT one of the basic strokes?

a) forehand b) volley

c) crosscourt d) serve

18. How would you describe the "ready position"?

a) player is on court ready to receive the ball

b) player is on the sidelines, ready to take the next court

c) player has begun to prepare the stroke

d) there is no such thing

19. When can a match be won by default?

a) when a player misses a shot

b) when a player doesn't win any games in the first set

c) when a player is late for a game

d) when a player serves from the wrong side of the court

20. What type of backhand creates the most power, most of the time?

a) one-handed b) Continental

c) two-handed d) depends on the type of racquet

21. Which of the following is NOT basic to making a stroke?

a) watching the ball

b) using a correct motion of the racquet

c) standing in correct place on the court

d) using correct footwork

22. Which is MOST important to a beginner?

a) power b) accuracy

c) depth d) steadiness

23. When must players stay on the same side of the court for receiving until a set is over?

a) in singles games b) never

c) in doubles games d) both a and c

24. After what games score do players change sides?

a) odd games (1,3,5)

b) even games (2,4,6)

c) after every game

d) players do not change sides

25. There is a lot of wrist associated with which stroke?

a) kicking serve b) flat serve

c) backhand volley d) forehand volley

26. A cross-court refers to?

a) serving to the service box on the other side of the net

b) proper follow-through across the body

c) a strategy used in doubles play

d) hitting the ball from the right side of the court to the left side of the other court

27. If you catch a ball hit by your opponent before it bounces, even if it is obviously going out, what happens?

a) you win the point anyway as it was obviously going out

b) nothing happens

c) the point is re-served

d) you lose the point

28. Where do the players serve from?

a) behind the baseline

b) behind the serving box

c) just inside the baseline

d) in no man's land

29. Which term does NOT apply to tennis?

a) top-spin b) under-spin

c) cross-over spin d) back-spin

30. The Continental grip COULD be used for which strokes?

a) serve b) forehand

c) volley d) a and c

31. Who has the FINAL say on a ball called out?

a) umpire

b) linesman

c) player closest to the ball

d) player who hit the ball

32. For a ball that touches the line?

a) it is called in

b) it is replayed, if it occurs on a serve

c) it is called out

d) it doesn't count

33. It is important to start the backswing early for which type of stroke?

a) ground stroke b) backhand volley

c) flat serve d) slice serve

34. During a doubles game, can a player leave the court while his/her partner keeps the ball in play?

a) only if they are winning

b) no

c) yes

d) only if player is hurt

35. Which of the following refers to "no man's land"?

a) it is the area between the baseline of the court and the fence

b) it is the area where a player is not standing

c) it is the area between the singles and doubles court line

d) it is the area between the baseline and the service line

APPENDIX D: Stimulus Materials for Experiment II

SOCCER

Poorly Structured Story

One day I was going against the Robins. They are one team, I'm on the Sparrows. I have a green t-shirt and they have a brown and white t-shirt. My last kick went right across the field and I almost scored a goal. Our first game against the Bluebirds I did some blocks. I did the leg block, knee block, stomach block, and the head block. I went in when we were against the Ducks. We won 9 to nothing. And in another game against the Seagulls we won 2 to 1. It started to rain. Someone tried to kick the ball and he fell on his back. He was covered in mud. He scored 3 goals and the other team scored 6. And when I was in goal they shot 11 goals at me. And the defense was hardly doing anything. And that was it 2 to 11. When I made my first goal it bounced off my leg. When I got home my ear was bleeding from a fly bite, and my nose hurt.

SOCCER

Well Structured Story

Last week my team the Sparrows were taking on the best team in the league, the Robins. Davie on our team usually goes offside about 7 times a game. At the start of the game it happened, but we still scored in the first 5 minutes. Our defense were playing well and our forwards were having a lot of shots but they wouldn't go in. By half time Davie had about 4 offside calls. After half, every time we crossed it over to try to score, Davie was offside. Our coach took him off the field. In the last 5 minutes they scored a goal on us. Davie came back on, scored and he wasn't offside then, so it was 2 to 1. We played defense for the last 5 minutes and they had a few chances. In the last 1 minute they got a penalty shot because one of our teammates hands the ball inside the penalty area. And then one of their best players missed the penalty shot. So we won the game 2 to 1. Then we had a celebration because we beat the best team in the league.