Deliberate Practice and Expertise in the Martial Arts: The Role of Context in Motor Recall

by

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A thesis submitted to the School of Physical and Health Education
in conformity with the requirements for
the degree of Master of Arts

Queen's University
Kingston, Ontario, Canada

June 1997

0-612-20652-1

Abstract

This study was conducted with two principal objectives: (a) to investigate the influence of context in the acquisition of novel motor sequences, and (b) to further test whether Ericsson, Krampe, and Tesch-Römer's (1993) theory of deliberate practice transfers to the athletic domain. Ten expert and ten novice martial arts students performed two motor recall tasks and completed an activity questionnaire related to their participation in karate.

For the first recall task subjects replicated two structured and two unstructured sequences of karate techniques. Serial accuracy analyses showed a skill level by structure interaction, indicating that experts were superior for structured sequences only. During the second recall task subjects recalled four sequences that were either demonstrated with context or without. The presence of context did not benefit recall for the experts. Analyses of the novice group's performance showed that recall was initially hindered by the presence of context, thus demonstrating that pairing context with motor information is not an effective instructional strategy during initial acquisition.

Evaluation of the role of deliberate practice in expert performance was assessed through retrospective questionnaires. Analyses of the data indicated that the activities considered most relevant to martial arts performance were also deemed the most enjoyable. These activities also rated high on dimensions of mental concentration and physical effort. An assessment of the expert group's time spent participating in relevant activities indicated that they increased their

participation with others until the year that they achieved their black belt. Time spent participating in relevant practice activities alone was maintained over the course of their careers. The findings related to the relationship between relevance and effort, and relevance and enjoyment diverge from Ericsson et al.'s (1993) definition of deliberate practice, suggesting that adaptations should be made if it is to be considered a general theory of expertise.

Acknowledgments

My graduate work at Queen's has been an invaluable learning experience. For this, I wish to express my gratitude to Dr. Janice Deakin for the guidance that she has given me throughout the past two years. Although I am sure we will always interpret sarcasm differently, Dr. Deakin's definition of excellence, academic and otherwise, has been inspiring.

In addition I would like to extend appreciation to Dr. Janet Starkes for the contributions that she has made to this thesis.

I would also like to thank the students of Martial Arts Canada for participating in this project. Further gratitude is extended to Dan Coles for recruiting our subjects and volunteering as our expert demonstrator.

Mom and Dad, your persistent encouragement and faith in my ability has meant the world to me. I chose my parents well!

Bren, you have been a great friend throughout our six-year (yikes!) gig at Queen's. Look out world, here we come! Heather, Doaner, Kirky, Lara, Lucie, and Mick...you're a crazy bunch. You know, I could not ask for a finer group of friends.

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Introduction

An increased interest in the underlying knowledge structures related to skilled memory performance has been the impetus for much of the research on expert performance. Investigations in both motor and cognitive domains have yielded consistent results; exceptional memory performance is the result of an elaborate knowledge base that has developed through extensive experience in a specific domain. It is surprising that the potential that these findings have for enhancing novice skill acquisition has not generated much research in the motor domain.

The first objective of this study was to assess whether pairing a verbal context with motor information is associated with superior recall of novel motor sequences. Very few studies have been conducted in the motor domain regarding the influence of context on recall performance. This research has been limited to the use of simple verbal labels in the recall of discrete movement information (Reeve & Proctor, 1983; Shea, 1977). In contrast, the cognitive domain abounds with investigations aimed at understanding how skill acquisition may be enhanced by manipulating the meaning associated with the target information (Chase & Ericsson, 1981; Chazin & Neuschatz, 1990; Helstrup, 1993; Wallace, 1994). This research suggests that a melody, or verbal elaboration may provide a meaningful context that improves recall performance.

A motor recall paradigm was employed in order to assess the relationship between context and recall and to determine whether it is related to the skill level of the performer. Based on commonly reported findings in the skilled memory literature, it was anticipated that expert and novice recall performance would be differentially influenced by an external context. If the results of the cognitive investigations transferred to the athletic domain, that is, if the accompaniment of a verbal context with movement information improved recall, such a strategy would have valuable implications for an instructional setting.

Most recently the focus of expertise research has shifted from the use of memory tasks to the investigation of the activities that comprise an expert's practice schedule. As such, deliberate practice research provides insight into how group differences accrue due to differential amounts of time engaged in different practice activities. Similar to skilled memory theorists, deliberate practice researchers have concluded that exceptional performance is the result of extensive practice by the individual in his/her domain.

The second main objective of the present investigation was to test the effectiveness with which Ericsson, Krampe, and Tesch-Römer's (1993) theory of deliberate practice transfers to the athletic domain. The results of recent work with athletes have not supported some of Ericsson et al.'s (1993) original deliberate practice research with expert pianists and violinists (Hodges & Starkes, 1996; Starkes, Deakin, Allard, Hodges, & Hayes, 1996b). It has been reported that the relationship between the enjoyment experienced from participation in highly relevant activities differs between athletes and musicians (Hodges & Starkes, 1996; Starkes et al., 1996b). Athletes also appear to differentiate between mental and physical effort, a dimension which was not considered by Ericsson et al. (1993). Finally, the types of activities that each domain has counted as deliberate practice have differed. Taken together, the reported findings of the research conducted with athletes and musicians suggest that the basic tenets of the deliberate practice framework must be adapted if it is to be considered a general theory of expertise.

A retrospective questionnaire similar to that used by Starkes et al. (1996b) was employed, which provided valuable information concerning the activities that the martial artists considered most relevant to their performance, along with the activities that comprised their practice schedules. Such knowledge has important implications concerning the specific activities that constitute deliberate practice for athletes, and thus, has potential regarding the design of the most effective training regimes.

Review of Literature

The scientific study of exceptional performance has origins in the pioneering work of Bryan and Harter (1899) on telegraphy operators. Attempts to determine the mechanisms responsible for superior performance by individuals continue today. There is considerable agreement that the advantage which expert performers display within a domain is the result of a superior utilization of any number of cognitive skills. Since most of the domains under investigation place high demands on the cognitive system for success, perhaps it is not surprising that there has been a convergence of opinion toward the cognitive explanation of superior performance. Similar agreement within the motor domain has been realized more slowly. Initially, genetic differences between individuals of varying skill levels was the favoured explanation of exceptional motor performance. Investigations into the identification of inherent, or 'hardware' abilities have not provided empirical evidence to support this view (Starkes & Deakin, 1984). In contrast, research into a cognitive, or 'software' explanation of exceptional performance has reported characteristic expert-novice differences on a number of cognitive dimensions, across a diverse range of motor skills (Allard & Starkes, 1991). These similarities have eventually led to a convergence of opinion in favour of a cognitive advantage in expert motor performance.

Much of the work within various motor skill domains has been based on the landmark studies of de Groot (1965) and Chase and Simon (1973). The experiment most often replicated from de Groot's chess investigations is the five-second recall task. Chase and Simon found that for structured middle game positions, the master (M) chess player was capable of correctly placing approximately 16 out of 25 pieces after only five seconds of viewing, while the class A player (A) and beginner (B) were only able to place 8 and 4 pieces, respectively. Since this superiority disappeared once game structure was removed, the notion of a larger short term memory (STM) capacity was discounted. For M, the pieces were 'chunked' into larger meaningful units. This means that the chess master was able to 'pick up' meaningful associations more quickly and accurately than the lesser-skilled players. While Chase and Simon's (1973) original work only used one subject per group, chess studies using larger sample sizes have replicated their findings (Charness, 1976; Frey & Adesman, 1976).

Using a multitask approach, Starkes (1987) set out to determine the relative contribution that inherent abilities made compared to cognitive skills in different skill levels of field hockey performers. Using twenty structured (depicting play around the striking circle and the net), and twenty unstructured (depicting transitional scenes) slides for one experiment, Starkes looked for a skill by game structure interaction similar to that found by Chase and Simon (1973). Given the large number of players on the pitch, viewing time for each presented slide was eight seconds. After viewing each slide, subjects attempted to replicate the positions of the players by placing magnetic markers on a small-scale field hockey pitch. A significant group-by-structure interaction reported that national players were significantly better than varsity athletes who, in turn, were better than the beginners. As expected, group differences were not observed for unstructured game information. Investigations in other sports such as soccer (Williams, Davids, Burwitz, & Williams, 1993; Williams & Davids, 1995), basketball (Allard, Graham, & Paarsalu, 1980; Starkes, Allard, Lindley, & O'Reilly, 1994), football (Garland & Barry, 1991), figure skating (Deakin & Allard, 1991), and ballet (Edmonstone, 1987; Starkes, Deakin, Lindley, & Crisp, 1987) revealed similar results. Analyses on simple reaction time, dynamic visual acuity, and coincident anticipation time tasks resulted in no between group differences. Since Starkes' (1987) results indicated that only the cognitive tasks discriminated between the three skill levels, she concluded that it is an elaborate declarative and procedural knowledge base that determines expertise in an open-skill sport such as field hockey.

One instance where a skill level-by-structure interaction was not observed was in Starkes, Caicco, Boutillier, and Sevsek's (1990) investigation of creative modern dancers. From the outset it was hypothesized that perhaps this group of experts may be an exception in that the very nature of their skill is to perform sequences of elements that are intentionally unstructured (Starkes et al., 1990). As a result, the memory structures required for the skilled creative dancer may be very different from the ballet dancer or figure skater, since the latter two performers rely greatly on the congruity of their movement sequences. A recall test of high frequency words was conducted in order to refute the argument that their expert dancers had larger memory capacities. Lack of group differences suggested that the purposely random nature of creative modern dance allowed for superior unstructured recall by the experts (Starkes et al., 1990).

Smyth and Pendleton (1994) also failed to show the classic skill level-by-structure interaction. The authors suggested that the nonsignificant interaction between ballet and nonsense movements was indicative of the expert's superior memory for both ballet movements and those which do not conform to Laban's principles. Some serious methodological flaws are apparent in Smyth and Pendleton's design, however, which may account for their discrepant findings. It is impossible to compare expert-novice recall differences for domain-specific information when the novice participants have had no prior exposure to the movements. The movements for each set (ballet, nonsense) were randomly selected, essentially creating an unstructured condition for the ballet movements according to the traditional expertise literature. Another difference between Smyth and Pendleton's design and other expertise investigations was that subjects recalled the movements in any order they wished. Serial recall is a more accurate reflection of expert-novice differences, since it is the recognition of the meaning between the movements which is thought to discriminate between skill levels.

The consensus in the field of motor expertise confirms the results observed in research using strictly cognitive skills; the amount of information that can be encoded during brief exposure to a schematic diagram is a function of a domain-specific semantic network or knowledge base. Much of the difference between expert and novice performance lies in the novice's inability to abstract meaningful associations from the presented chess position or sequence of elements simply because the novice does not have the knowledge base that would allow him/her to "see" them as meaningful (Allard, Deakin, Parker, & Rodgers, 1993).

It is important to consider that for cognitive and motor skill research alike where memory tasks have been used, the mechanisms accounting for exceptional performance in such tasks may only partially account for those processes underlying expert performance. As such one cannot be sure if the differences observed between skill levels are actually related to the subject's use of his/her relative abilities in the real-world undertaking of the skill. Similarly, it is not known how this superiority translates to chess or field hockey performance.

An investigation that was unsuccessful in obtaining skill differences using arbitrary lab tests, but elicited large differences for representative tasks was Chase's (1983) study of taxi drivers. Using a sample of 5 experts (18.2 years experience), 5 intermediate subjects (5.6 years experience), 5 novice subjects (0.7 years experience) and 5 control (non-taxi drivers, but 6.5 years driving experience), the cognitive mapping tasks conducted in the lab (i.e. map drawing, street naming, distance estimations, etc.), failed to elicit between-group differences. It was not until route-generation tasks both in the lab and in the field were conducted that skill differences became evident. Since finding the most efficient routes to specific destinations was a representative task for taxi drivers, it was suggested that these navigational skills were closely related to the subject's real-world undertaking of the skill. Transferring from the lab to the field improved performance for all of the groups, perhaps because there were more informational and contextual cues provided by the field setting (Chase, 1983). These results emphasize the importance of using tasks that are representative of what the expert encounters in his or her domain. Simply studying the byproducts of expertise does not further our understanding of how experts use this information to perform within their domain (Ericsson & Smith, 1993).

Skilled memory theory evolved from an attempt to improve the level of understanding of how experts use domain-specific information and how this translates into expert performance. The five principles of skilled memory theory were proposed by Ericsson and Polson (1988). First, exceptional memory is specific to the performer's skill domain. This relates to the structured-unstructured paradigm that has been used to discount a hardware explanation for recall; if the information is not domain-specific, the expert's performance will be comparable to that of a novice. Second, the ability to encode domain-specific information quickly develops with practice, and has been demonstrated with self-paced encoding paradigms. Third, the information is held within long term memory (LTM) and therefore may be recalled after long retention periods. Fourth, existing semantic memory structures are used by experts for encoding. Fifth, the information stored in LTM is accessible at recall due to the retrieval devices (mnemonic aids) that are implemented during initial encoding. While both cognitive and motor skill investigations have studied different tenets of the theory, support has been consistent across both domains.

Expertise in physics is a cognitive skill that has many parallels with the motor domain (Anzai & Yokoyama, 1984; Chi, Feltovich, & Glaser, 1981). Given its inherent problem-solving nature, it is not surprising that the expert-novice differences observed in physics are similar to open-skill sports. Chi et al. (1981) investigated expert-novice differences in the organization of physics knowledge and were able to provide evidence in favour of skill being mediated by a domain-specific knowledge base. It was through a sorting paradigm that the knowledge structures best discriminated between the skill levels. Using PhD students as their experts and physics undergraduates as their novices, Chi et al. (1981) had subjects sort twenty-four physics problems into groups defined by similar solutions. Subsequent cluster analyses revealed little agreement between the two groups concerning which problems belonged to the same category. Novices sorted the problems according to their surface attributes, such as type of object used or physical terms mentioned. In contrast, experts were guided by the physics principle inherent to each problem for sorting. Since the novices were concerned only with the superficial characteristics of the problems, their categories collapsed across different principles. Knowledge structures were thought of as problem representations, or abstract cognitive structures associated with a specific problem (Chi et al., 1981). These representations were considered to directly reflect the extent of the semantic network, or organization of one's knowledge base pertaining to physics. Accordingly, the differences observed between experts and lesser-skilled individuals were thought to be due to a poorly developed semantic network that did not permit the abstraction of a rich representation.

Garland and Barry (1991) administered a sorting task adapted from Chi et al. (1981) to determine the bases upon which expert and novice football players sorted schematic diagrams. Results showed that novices used superficial sorting criteria such as number of players depicted in order to categorize the diagrams. The experts' sorting criteria were much more discriminating, thus allowing for nonoverlapping clusters of the underlying dynamics (i.e. defensive techniques, kicking techniques, running plays) depicted in the diagram. Insight into the criteria that open-skill athletes use to categorize allows for inferences regarding the elements that they consider relevant in decision-making, which is often a limiting factor in open-skill competition (Garland & Barry, 1991). It appears that experts have highly elaborated sorting criteria due to a highly organized semantic network in LTM which allows for superior pattern recognition. Research in the motor domain has consistently shown that the depth of processing, or the ability to abstract underlying principles is a function of skill level (Allard & Burnett, 1985; Garland & Barry, 1991).

Chase and Ericsson (1981) undertook an investigation to evaluate the acquisition of expert performance in a digit span task. They tracked the performance of a single subject (SF) whom they trained to become an expert at the digit span recall paradigm. The task was to recall sequences of random digits which were read at a rate of one digit per second. The sequence was increased by one digit if SF recalled it in the correct serial order, or it was decreased by one digit if SF recalled incorrectly. This same procedure was implemented in one-hour sessions, two to five days a week, until the subject had accumulated approximately two hundred and fifty hours of practice (Chase & Ericsson, 1981). When SF first began to practice, his STM capacity was within the expected range of five to nine items (Miller, 1956). Similar to most subjects when asked to recall random sequences of stimuli, SF initially attempted to encode the digits phonemically and rehearse them until he was required to recall (Chase & Ericsson, 1981). Over the course of two years, SF's skill level increased to where he was able to recall 80 digits. However, when he was given consonants to memorize, his STM capacity returned to a level of seven digits.

It was through an analysis of the subject's verbal reports that the development of a detailed mnemonic system was evidenced (Chase & Ericsson, 1981). SF was an accomplished long-distance runner who learned to encode the digits presented to him as running times. In effect, he was using this extensive declarative knowledge base to recognize patterns of digits (i.e. world record times) and encode them accordingly. SF's STM capacity never increased because he never had more than five to nine chunks of digits stored. In accordance with skilled memory theory, the digits were successfully recalled because they were encoded as running times which served as retrieval structures from LTM. With practice, SF increased his ability to integrate his existing semantic memory of long-distance running with that of the digits in STM to make them accessible upon recall. The rules of his mnemonic system developed to the point where he was able to encode digits that could not be encoded as running times. For example, certain combinations of numbers were encoded as ages. Also consistent with the tenets of skilled memory theory was the finding that both the self-paced encoding and the retrieval times decreased with practice (Chase & Ericsson, 1981). The authors concluded that through existing knowledge located within LTM the expert can circumvent the expected time and capacity limitations imposed by the information processing system.

A second subject (ES) participating in Chase and Ericsson's (1981) investigation never developed a mnemonic system and withdrew after only two weeks of practice. This subject did not show any signs of recall improvement. In contrast, another subject (DD) was trained to use SF's mnemonic strategy from the beginning of acquisition and displayed a learning curve similar to SF (Chase & Ericsson, 1981). Thus, the provision of an effective learning strategy, or mnemonic was proven useful for the development of digit span expertise.

A strength of Chase and Ericsson's (1981) digit span research is that the progression of skill development was observed, and thus, the cognitive changes that accompanied improvements in performance could be analyzed. Most expertise investigations study individuals that are already performing at an expert level. Insight into how the skill developed over time cannot be attained without a baseline measurement of the expert's initial ability. By studying the parallel cognitive processes, Chase and Ericsson demonstrated that no change occurred in SF's STM capacity. Instead, it was the development of a powerful mnemonic system that accounted for performance improvements. This research also provided evidence for domain specificity of skilled memory, since transfer from digits to consonants effectively brought SF back to the performance level of a novice.

A less contrived investigation of skilled memory performance is Ericsson and Polson's (1988) study of an individual's exceptional memory for restaurant orders. An 'expert' waiter (JC) was used to study the retrieval cues incorporated during encoding which facilitated the recall of four-category dinner orders. JC used elaborate mnemonic strategies to chunk several individual items into specific categories. At encoding, he generated internal representations of four items for each category which served as effective retrieval structures at recall. Also in support of skilled memory theory, the time taken for JC to encode these orders decreased with practice (Ericsson & Polson, 1988). The authors inferred the use of LTM processes, since JC correctly recalled a high percentage of orders when tested after each session. For surprise recall tests he was also able to recall eighty percent of the orders that he encoded during work that day (Ericsson & Polson, 1988). A point of divergence from the skilled memory framework in this research was JC's apparent ability to transfer his exceptional memory for dinner orders to different stimuli (Ericsson & Polson, 1988). One must be skeptical of this conclusion, however, since the structure in which the novel information was provided to JC was maintained. Thus, it is possible that the mnemonic strategies that JC developed for dinner orders were used to recall the transfer stimuli.

The first test of skilled memory theory in the motor domain was conducted by Deakin and Allard in 1991. They demonstrated that many of the memory skills characteristic of digit span (SF) and restaurant order (JC) experts are similar to closed motor skill experts such as figure skaters. These convergent findings may be attributed to the fact that figure skaters, much like SF and JC, are required to recall long sequences of domain specific information.

Deakin and Allard (1991) employed a structured-unstructured recall paradigm to discredit a hardware account for superior memory performance by their expert group. When subjects were required to recall as much as they could in order from sequences of eight footwork elements, analysis of variance revealed a significant skill level-by-sequence interaction with the experts only displaying superior accuracy for the choreographed sequences. In a subsequent attempt to determine if it was LTM that was used by the experts for encoding and retrieval purposes, the skaters were tested in four recall conditions; immediate recall, unfilled delay, counting backwards for 30 seconds, and skating for 30 seconds (Deakin & Allard, 1991). If the skaters were not using LTM for encoding purposes, then the interpolated tasks would have caused a decrement in recall accuracy. Since the main effect of condition was nonsignificant, the authors concluded that figure skaters are similar to other skilled-memory experts in that they utilize existing knowledge from LTM for learning purposes. Use of LTM was also evidenced by the strong primacy and absence of recency effects, which was indicative of strategic processing (Cohen, 1984; Edmonstone, 1987; Helstrup, 1989).

Similar to figure skating, ballet dancers are required to commit to memory a pre-determined program of elements comprising sequences. The more skilled the dancer, the greater his/her repertoire for both movements and sequences. In 1987, Edmonstone investigated the nature of the memory processes used by dancers during recall, with a specific interest in how dancers recall familiar elements in a novel sequence. While dancers have a motor program for certain elements (dependent upon their skill level), it is not known how these elements are encoded into a novel sequence (Edmonstone, 1987). Correlation analyses indicated that the higher the skill level of the dancer, the greater the discrepancy observed between structured and unstructured recall. A skill level-by-structure interaction was also observed, with structured sequences significantly discriminating the skill levels. Similar to other researchers, Edmonstone concluded that it was the semantic connections between the elements that the more highly skilled dancers recognized and used to store movement units in LTM. These patterns or associations were not apparent for the unstructured sequences, so units of elements could not be successfully encoded. Further support for the use of LTM for encoding purposes was provided by a strong primacy effect for the choreographed sequences.

Starkes et al. (1987) studied dancers from the National Ballet School of Canada and provided further support for the assumption that structured conditions are conducive to the 'chunking' of sequences of movements due to the expert's ability to 'tap' his/her LTM. While the expert dancers displayed a higher probability of recall, post hoc analyses demonstrated that it was during the structured verbal and motor conditions that this superiority was demonstrated. In an experiment that tested the expert dancer's ability to recall sequences of eight elements in conditions with and without music, no significant performance differences were found during the first seven elements. However, t-tests conducted for the eighth element indicated that performance suffered significantly in the absence of music. While this study provided evidence for the influence of music as a mnemonic aid, this finding was not strong, since only one element within the sequence was affected. While the use of mnemonic or retrieval structures was not evident in Deakin and Allard's (1991) figure skating study, it was concluded that perhaps the expert skaters had developed the ability to quickly 'tap' their extensive semantic memories. It is worth noting, however, that testing during this experiment occurred without music, which may prove to be a mnemonic aid in figure skating (Deakin & Allard, 1991).

The literature in the field of expertise has consistently provided empirical support for the cognitive, or 'software' explanation of skilled performance. When applied to the expert memory framework, a number of similarities become evident between experts in both motor and cognitive activities. Cognitive and motor skill experts alike have the ability to select, encode, and retrieve from LTM domain-specific information in a manner that is much different than that of their novice counterparts. While memory capacity remains constant, it is an elaborate, domain-specific knowledge base that allows exceptional performers to use complex mnemonic strategies and retrieval structures that free them from potential processing limitations (Dempster, 1985; Salthouse, 1991; Starkes, 1993).

Deliberate Practice.

While skilled memory theory has been primarily concerned with how an expert's use of domain specific information translates into exceptional performance, the foremost objective of deliberate practice theorists is the determination of how one becomes an expert in his/her domain. Deliberate practice represents a most recent move in expertise research towards studying exceptional performance without implementing memory tasks (i.e. 5 second recall, structured/unstructured recall). By investigating the actual activities that comprise an expert's time, deliberate practice research offers a unique understanding of how group differences accrue as a result of differential amounts of time devoted to different activities. Determining the role that specific activities play in the development of expertise has a number of important implications for maximizing performance improvements.

The framework for deliberate practice was originally developed by Ericsson et al. (1993) in their investigation of violinists (i.e. 'music teachers', 'good violinists', and 'best, most accomplished violinists'), and pianists (i.e. amateur pianists and professional pianists) varying in degree of expertise. The results of these two studies were very similar. Consistent with the argument of the cognitive advantage, Ericsson et al. hypothesized that expert performance was the direct result of acquired domain-specific knowledge and its accompanying skill. The theory suggested that if the most important elements of practice could be determined, and if these specific activities were practiced a high proportion of the time, then maximal improvements in performance would be observed. In addition, the theory predicted that at least ten years of intense preparation emphasizing these activities were needed to reach expert levels of performance in any given domain. Thus, innate talent had no role in the theory of deliberate practice.

The four tenets of the deliberate practice framework are outlined by Ericsson et al. (1993). First, there is a direct, positive relationship between level of expertise and amount of deliberate practice. Second, deliberate practice activities elicit maximal improvements in performance. Third, deliberate practice activities are effortful (mental work), and thus, can only be sustained for limited amounts of time due to fatigue. Fourth, while deliberate practice activities are considered to be highly relevant to performance, they are not inherently enjoyable.

From retrospective questionnaires and diary information, Ericsson et al. (1993) identified a number of differences in practice conditions between the three groups of violinists. Subjects were provided with a taxonomy of activities related to music and everyday activities. First, subjects estimated the amount of time that they typically engaged in these activities at various stages in their music careers. Second, they rated each activity using a 10-point scale (i.e. 0=low, 10=high) on measures of relevance, effort, and enjoyment. For each rating category (i.e. relevance, effort, enjoyment), the mean rating for each activity was compared to the grand mean rating for all of the activities. Since no systematic between group differences were discovered for these ratings, the data were collapsed across the three groups. In addition to the retrospective report, a detailed seven-day diary was kept by each subject for reliability purposes. No differences were found between the best and the good violinists. However, by comparing the retrospective reports with the diary data, it was determined that the best violinists were more accurate than the other groups at determining the amount of time spent engaging in leisure pursuits. This indicated to the researchers that perhaps the best groups were more precise because of their more structured involvement in music.

With respect to the estimates of accumulated amounts of practice until eighteen years of age, the best violinists (7410 hours) had practiced significantly more than the good violinists (5301 hours) who, in turn, had practiced significantly more than the music teachers (3420 hours). In comparison, by eighteen years of age the professional pianists (7606 hours) had practiced significantly more than the amateurs (1606 hours). It is important to note that these estimates represented the number of hours spent practicing the violin/piano alone, which was the activity considered most relevant to performance. According to these data there was complete agreement for the positive relationship between accumulated deliberate practice and degree of expertise.

Also consistent with the deliberate practice framework were the activities rated both extremely relevant and effortful. The high ratings of effort for practicing alone were supported by their limited duration and estimates of time spent sleeping. While no differences were found between the best and good violinists, these two groups slept (60 hours/week) significantly more than the music teachers (54.6 hours/week), which was thought to indicate the relative fatigue that resulted from differential amounts of time spent practicing alone. However, the amount of sleep did not differentiate between the professional and amateur pianists.

A third line of support cited by Ericsson et al. (1993) was of those activities considered highly pleasurable, only group performance and listening to music were rated as highly relevant to performance improvement. One must question these conclusions, however, since none of the highly relevant activities were significantly lower than the grand mean for pleasure.

Within the past two years, a number of investigations have been conducted with the purpose of assessing whether the deliberate practice framework would transfer to the athletic domain (Helsen & Starkes, 1996; Hodges & Starkes, 1996; Starkes et al., 1996b; Starkes, Helsen, & Hodges, 1996a). Starkes et al., (1996b) investigated the role of deliberate practice in wrestling and figure skating expertise. The wrestling research considered four groups; current club, retired club, current international, and retired international wrestlers. The figure skating research consisted of athletes on the national and junior national teams. In an attempt to determine which activities constituted deliberate practice, a number of activities were divided into four groups; practice alone, practice with others, activities related to wrestling/figure skating, and everyday activities not related to wrestling/figure skating. Similar to Ericsson et al.'s (1993) musicians, the athletes estimated the amount of time they typically spent in each activity at various times throughout their career. They also rated the activities according to relevance to performance improvement, effort (physical work) required, concentration (mental work) required, and enjoyment experienced. As a reliability check for the retrospective information, this study also had subjects keep a week-long diary of their participation in various activities. For these data there were no activities that rated both highly relevant and significantly lower than the grand mean for enjoyment. In fact, activities such as working with a coach, mat work for the wrestlers, and on-ice training for the skaters rated significantly higher than the grand mean for both relevance and enjoyment. Research into the team sports of soccer and field hockey has corroborated many of the findings reported in the figure skating and wrestling investigations (Helsen & Starkes, 1996; Starkes et al., 1996a).

Some similarities between the music research and the research conducted with athletes concern the activities that are deemed most relevant to performance. Both have determined that it is the activities most related to what individuals do during their actual performance (i.e. practice playing the violin, mat work, on-ice training, games and tactics, technical skills), and work with a mentor (i.e. violin lessons, work with coach) that are most important (Ericsson et al., 1993; Helsen & Starkes, 1996; Starkes et al., 1996a; Starkes et al., 1996b). In addition, there appears to be a close, monotonic relationship between athletes and musicians for cumulative hours of practice at different stages in their careers.

While Ericsson et al. (1993) have introduced an invaluable method for studying expertise in a most natural form, they have experienced some difficulty in providing empirical support for some of the theory's basic tenets. Furthermore, the research conducted by Starkes et al. (1996b) failed to provide support for any activities that fit the definition of deliberate practice as outlined above. Contrary to the framework, wrestlers and figure skaters enjoyed engaging in the activities that they considered to be highly relevant to performance in their specific domains. Conforming with the framework, however, was a strong positive correlation between relevance and effort or concentration required.

The potential for maximizing improvements in performance is an important implication of deliberate practice research, however, as of yet there is not a clear working definition of which activities constitute deliberate practice. While Ericsson et al.'s (1993) original theory was general so as to apply to other areas of expertise, research in the athletic domain has demonstrated that if the theory of deliberate practice is to be effectively applied, its basic principles must be adapted (Starkes et al., 1996b).

Maximizing Performance Improvements.

While a number of studies have illustrated that cognitive attributes outweigh hardware characteristics when investigating expert-novice differences, very few have attempted to account for *how* an understanding of this cognitive advantage can be used to hasten expertise (McPherson & French, 1991; Thomas, French, & Humphries, 1986). Given that the primary goal of coaching/instruction is to facilitate the development of domain-specific knowledge structures, it is surprising that more research has not addressed this specific issue (Newell, Rosenbloom, & Laird, 1989). Insight into *how* an elite athlete acquires the classic cognitive ('knowing') advantage has many practical implications for helping novices to achieve their maximal potential.

When a new motor skill is acquired, it is critical that the learner remembers how to repetitively execute the same movements in a similar manner if he/she is to become proficient in activities such as figure skating, ballet, or the martial arts. If the correct movement is to be recalled, a sufficient amount of information must be encoded, stored, and be accessible for recall purposes. There are a number of characteristics that influence these memory processes; characteristics that can be manipulated so as to facilitate the acquisition of a motor skill (Magill, 1984). An important influence on remembering movement information is the degree of meaning inherent to the movement itself (Magill, 1984). Specifically, a movement will be considered meaningful if it is paired with prior knowledge (Bellezza, 1982).

The research conducted in the motor domain has been limited to semicircular positioning or computer joystick tasks in the recall of discrete movement information (Reeve & Proctor, 1983; Ho & Shea, 1978; Shea, 1977; Winther & Thomas, 1981). Interest in motor research on the facilitation of recall has not gone beyond defining meaning as the pairing of simple verbal labels with these discrete movements. The practical implications that this research has for motor skill acquisition are that it becomes apparent that there are a number of strategies that the learner/instructor can use to increase the meaningfulness of a movement. Through the processes of labeling (pairing movement with a useful label) or elaboration (adding additional information), memory for a discrete positioning skill can be significantly improved (Magill, 1984). Since these positioning tasks are not representative of the skilled movements required of the ballet dancer, figure skater, or martial artist, relevant parallels cannot be drawn between these tasks and complex movements required of the athlete.

In direct contrast with work in the motor domain, the cognitive domain reports many investigations aimed at understanding how memory can be improved and learning hastened. For example, Chase and Ericsson (1981) demonstrated that digit-span expertise may be hastened if a subject (DD) is provided with a useful mnemonic strategy from the beginning of acquisition. Similar to SF, DD was also a long distance runner and was able to benefit from SF's strategy of encoding digits as running times.

Research into the utility of musical mnemonics for remembering text is most common (Bartlett & Snelus, 1980; Chazin & Neuschatz, 1990; Rubin, 1977; Scruggs & Brigham, 1991; Wallace, 1994). The melody that accompanies the text is another piece of information, so it must provide more than just a unique context or it will place excessive demands on recall effort. Using undergraduates as subjects, Wallace (1994) investigated whether the accompaniment of music could be used to improve recall accuracy. Over five recall trials, subjects were exposed to three verses of a novel ballad in either a sung or spoken condition. Analyses showed that while verbatim recall was significantly greater for the sung condition, a significant trial-by-condition interaction indicated that on the first trial the benefit of melody was not observed. A twenty-minute retention trial also illustrated the beneficial influence that music can have for text recall. Wallace suggested that it was the repetitive nature of the melody that benefited recall performance. Specifically, it was not until the melody was learned by the subject that the advantage of its accompaniment with the text was observed. Repetition facilitates recall because of the accompanying decrease in processing demands. Without repetition, the potential that the information inherent in the melody has for text recall will not be demonstrated (Wallace, 1994).

Recall will be facilitated if any stimulus is effective in elaborating upon a number of properties contained within the text (Crowder, Serafine, & Repp, 1991). With respect to this issue, Wallace (1994) also manipulated the amount of exposure to the melody. In the previous experiment, subjects heard the melody three times for each trial, while in the second experiment subjects were exposed to the melody only once for each trial (the melody did not repeat for each verse). Results of this experiment demonstrated that if the melody was not completely learned, it did not prove beneficial to verbatim recall. The presence of the single verse melody actually proved to be more of a distractor to recall effort. Thus, in the absence of repetition the meaningful information inherent to the melody is not easily learned. Only after repetition and sufficient learning of the music will the information within the melody be accentuated and recall improved.

Wallace (1994) also conducted an experiment to ascertain whether it is only rhythmical information that the melody provides when paired with text.

Subjects were assigned to either a sung or a spoken condition that included rhythmically stressed syllables accompanied by a background metronome beat. If music only provided rhythmical information, then there should be no between group differences for verbal recall performance. Analyses confirmed that the performance of the music condition was superior to the rhythmically spoken condition. Analyses conducted on error data also showed that the sung condition was more accurate in recalling the correct number of syllables present in each line. Thus, music provided much more than just rhythmical information when paired with text (Chazin & Neuschatz, 1990; Scruggs & Brigham, 1991; Wallace, 1994). It was the abstraction of information that results from this pairing that enhances memory. It may be used as a valuable mnemonic aid that increases the meaning of the text by chunking words within the text, and determines the length of text lines, thus putting specific constraints on the number of possible responses (Wallace, 1994). As an access point, merely thinking about a specific part of the melody will trigger the text that coincides with that location.

Considering the motor domain and the finding by Starkes et al. (1987) that music served as a mnemonic aid for the last element of a structured ballet sequence, it may have been the richness of the information provided by the interaction with the music that elicited improved recall for the last element. Perhaps the association of the music with the elements created a context that accentuated the structure of the sequence, providing information beyond that which could be provided by simple verbal labels.

Helstrup (1993) investigated whether simple, subject-performed tasks could be integrated with verbal contextual information to improve recall. Specifically, he studied whether a loci mnemonic (agent, time, place) at the time of encoding of a verb-noun action (i.e. brushing teeth) would benefit recall of a list of actions. Helstrup hypothesized that while item-differentiation would not enhance recall, relational encoding would have a beneficial memory effect because the actions would become strung together within a common framework. According to this argument, providing item-specific contexts would be ineffective because the actions themselves were already unique so adding extra information would not improve recall. While a main effect of context was reported, the author did not provide post hoc results to indicate significant differences between the three context conditions; no context, item-specific, whole context plus item-specific. However, it does appear that recall was enhanced by the provision of some form of context. It should be noted that for the third experiment, subjects were only tested for free recall performance. In accordance with Roediger (1980), a more obvious mnemonic advantage of context may have been elicited if serial recall had been measured. "[S]ome experimental failures to show that mnemonic devices are effective may have been due to testing only item information" (p. 560). Also, Helstrup (1993) asked his subjects to perform only one recall trial. Since the subjects were far from

100% free recall accuracy, perhaps the benefit of context would have become more apparent had additional trials been allotted so as to ensure that the context had been integrated.

The effect that context has on recall accuracy for an applied motor skill is currently unknown. The present study will attempt to identify this relationship. It seems intuitive to hypothesize that if it is to be beneficial, the context must be considered meaningful at the time of encoding, and be successfully integrated with the motor information so that it may provide memory tags for the elements when recalling the motor sequences. These expectations are primarily grounded in both the expertise literature and the research that has considered the facilitative affect that music and verbal elaboration has on recall. It is anticipated that including a context with the demonstration of structured motor sequences will accentuate the semantic relationships between the elements for the novices. This elaboration will not be needed by the experts, since they have developed the ability to 'see' the inherent structure of the sequence and create their own internal context. It is not expected that the benefit of context will be apparent on the first exposure, as it will not be until the context is learned that an advantage will be observed. From an instructional point of view, if recall is more accurate in the presence of context, such a strategy would be valuable in hastening the acquisition of novel motor sequences.

For every new domain that is studied, the possibility of a 'hardware' explanation for skilled memory performance must be considered (Edmonstone, 1987). Through the use of a structured-unstructured recall experiment, it is anticipated that the present investigation will demonstrate the classic skill-by-structure interaction that has been consistently observed in the expertise literature. While not a representative task, this is a valuable paradigm used to infer that an expert's superior performance is not due to a larger structural capacity, but instead, results from reliance on an elaborate LTM base of skill-specific information.

With respect to the deliberate practice research, further work is needed for a better understanding of the amount and distribution of specific activities that exceptional performers engage in. This study will attempt to further the current understanding of the activities that constitute deliberate practice in the athletic domain. It is anticipated that ratings for relevance, effort, concentration, and enjoyment will be similar to Starkes et al.'s (1996) figure skating and wrestling data. From an instructional point of view, an accurate picture of the activities that are considered most relevant to performance, along with knowledge of the amount of time experts engage in different activities has important implications regarding the design of effective training schedules.

Method

Subjects

Two groups of ten students participating in the Martial Arts Canada programme (chikarajitsu) served as subjects for this investigation. One group (expert; $\bar{x}$ age=18.4 yrs.) were first-degree black belt students, while the other group (novice; $\bar{x}$ age=17.4 yrs.) was comprised of both green and orange belt participants. The novice group had an average of 1.2±0.4 years of karate experience, while the expert group had approximately 6.9±1.1 years. Individual subjects were matched by age between groups with the overall age range of the sample being between thirteen and twenty-six years. Subjects were familiar with and physically capable of performing the techniques that were demonstrated in the various sequences (kata).

Apparatus

A video camera (Quasar X12) was used to record an expert demonstration of four kata for each of two experiments. Testing sessions were also recorded for subsequent scoring purposes. The model chosen to demonstrate the sequences was a third-degree black belt instructor in the Martial Arts Canada programme. He created the novel kata that were used in both experiments. He, with a second-degree black belt instructor, scored the data following collection.

For the first experiment four kata were demonstrated in one of two conditions; with context or without. The first kata was comprised of fourteen elements, while the second and third kata had thirteen elements each. The fourth kata contained twenty-two elements. Context was defined as the verbal elaboration, beyond labeling, of the techniques within the specific kata. The kata with context were depicted as a 'battle', where the model described during the demonstration, the techniques that he used in a battle against various imaginary attackers. The techniques used were elaborated upon by describing the intent of each technique (i.e. offensive or defensive), where he was aiming, if the technique was blocked or landed, and whether it was countered. In the no-context condition the same demonstrations were used with the commentary removed. The demonstrations were performed at a speed that was slow enough for the individual techniques to be recognized, but not so slow so as to disrupt the flow of the sequence (approximately 3-4 seconds per element).

For each kata, the model first executed the whole sequence, then broke it down into units of movement in only one direction, and finally executed the whole kata one final time. All of the kata were novel, with the stipulation that no two sequentially dependent techniques in one kata were repeated in another. Subjects were exposed to all four kata. For each kata half of the subjects in each group viewed it with context.

During the second experiment, two structured and two unstructured kata were demonstrated. The first and second structured kata contained twenty-four and twelve elements, respectively, while both of the unstructured kata were comprised of nine elements . A structured kata was defined as a sequence of techniques that progressed in a logical fashion. An unstructured kata was defined as a sequence that followed no logical progression, but instead represented the random compilation of a number of techniques. Each kata was demonstrated two times without context, at a speed that was slow enough for the individual techniques to be recognized (approximately 2 seconds per element). All subjects were exposed to both of the structured and both of the unstructured kata .

A paper and pencil questionnaire was used to gather information related to the length of time that subjects had been involved in the martial arts, the amount of time per week they practiced, and other information related to their involvement in this area. The design of the questionnaire was similar to that used by Starkes et al. (1996b). A total of 31 activities relevant to martial arts training were determined in advance with an expert martial arts instructor, and were broken down into four categories; practicing with others, practicing alone, other practice related activities, and everyday activities unrelated to karate. Subjects were required to estimate the amount of time from their first year of karate and for every second year until the present that they spent participating in these activities. A number of time ranges were provided from which the subjects could choose, however they were encouraged to provide exact time estimates when possible. In addition, they were required to rate each activity on a scale from 0 (low) to 10 (high) for: relevance to improving karate performance, effort (physical work) required to perform the activity, enjoyment gained from participating in the activity, and concentration (mental work) required to perform the activity.

Procedure

Testing took place at the martial arts school where the subject participated. Subjects were tested individually to control for the influence of others. Participation in both experiments and completion of the questionnaire occurred during one session that lasted approximately ninety minutes.

Upon arrival, subjects were given detailed instructions regarding the format of the questionnaire and the manner in which the different sections should be completed. Since the biographic section asked subjects to provide a record of dates concerning their advancement through the martial arts system and participation in clinics/seminars and competitions, subjects were asked to bring a record of these dates with them in order to avoid speculation.

The first experiment was completed following the questionnaire, with the exception of five subjects who completed the questionnaire following the motor recall experiments. The order of exposure to kata with context and without context was counterbalanced. Subjects observed a video demonstration of four kata. The first and third demonstration represented a full demonstration of the kata in its entirety. The second demonstration involved a breakdown of the original kata into segments, with each segment involving movement of the model in only one direction. For the kata that were observed without context, a final whole demonstration was provided with context. Following each demonstration, subjects physically replicated the sequence/segment that had been observed. This same procedure was used for all four of the kata in the first experiment. A summary of the design for the first experiment is presented in Table 1.

Following the context versus no context experiment, subjects completed the second experiment. The order of exposure to the structured and unstructured kata was also counterbalanced. Subjects observed the demonstration of four more kata, two times each. Subjects physically replicated each sequence following the second demonstration.

TABLE 1
CONTEXT VERSUS NO CONTEXT ON MOTOR RECALL

ACQUISITION OF KATA						
Trial 1	Breakdown Trial (segmental recall)				Trial 2	Final Trial for No Context Kata
demo whole kata, then recall	see techniques to the left with/without context, then recall	see techniques to the right with/without context, then recall	see techniques in forward direction, then recall	see techniques in backward direction, then recall	demo whole kata, then recall	for kata without context, one final demo of whole kata with context, then recall

Experimental Design

The independent measures for the first experiment were skill level (expert, novice), condition (with context or without), and trial (3). The independent variables for the second experiment were skill level (expert, novice), and structure (structured, unstructured). For both experiments the dependent measures were absolute and serial position accuracy. Serial accuracy is a very strict test of memory, since the elements must be recalled in the exact order they were demonstrated. Displacement of an item at the beginning of recall results in all subsequent items being scored as incorrect. Absolute accuracy is a much less stringent test of recall because displacement of elements does not have a negative effect on the score; the only requirement is that the element is recalled, regardless of its serial position within the sequence. The rationale behind studying both serial position and absolute accuracy is that one measure provides information that would be masked by the other. Major differences between the two scores would indicate a general recollection of the demonstrated elements with an inability to recall their precise serial order. Since the sequences were comprised of different numbers of elements, the accuracy measures were expressed as percentages for purposes of comparison. Analyses were run at a significance level of .05. Tukey LSD *post hocs* were used to determine where differences were located for significant main effects and interactions.

Questionnaire Data

Several analyses were conducted on the information provided by the questionnaire in order to make both between and within group comparisons. Subjects used the scale (0-10) to rate the four categories of activities on dimensions of concentration, effort, enjoyment, and relevance. Bonferroni t-tests were used (at $p \leq .05/31 = .0016$) to determine the values that were significantly higher and lower than the grand mean for the ratings of relevance, effort, concentration, and enjoyment. Since there were no systematic between group differences (determined with independent t-tests), the rating data were collapsed across the expert and novice groups. Finally, a Spearman correlation analysis was conducted to evaluate the interrelationships between the four dimensions on which each activity was rated.

Regarding the time data, analyses of variance ($p \leq .05$) were conducted to determine whether experts and novices were spending differential amounts of time engaged in practice. Since the novices had been involved for an average of 1.2 years, between group comparisons could only be made for the first year of participation. For this analysis, both groups were required to estimate the number of hours per week that they participated in the activities, which were grouped into four different categories. From these data it was determined whether there were group differences during the first year of participation for both total time spent per week in all karate-related activities, and the amount of time that was spent participating in those activities considered most relevant.

Since all of the experts had been involved in karate for at least five years, further analyses of their retrospective time estimates were conducted to determine whether they were spending differential amounts of time engaged in different activities as a function of year. That is, the first year, third year, black belt year, and most recent year of participation were compared for both total time per week engaged in all karate related activities, and time per week devoted to the significantly relevant activities.

Results

The data from both expert scorers were compared to establish a measure of inter-rater reliability. Correlation analyses revealed that 98% of the variance of the first scorer's structured-unstructured data could be accounted for by the second scorer ($r=.99$, $r^2=.98$), $p<.05$. For the context-no context experiment, approximately 81% of the first scorer's data could be predicted by the second scorer ($r=.90$, $r^2=.81$), $p<.05$. Due to the high degree of agreement between the experts, only one scorer's data was used for the following analyses.

Experiment 1: Context - No Context Analysis.

The results of a test of normality across variables revealed that both the serial position and absolute accuracy data for this experiment required power transformations. All analyses were run on both the raw and transformed data. With only one exception, results were similar for the serial position data. For ease of interpretation, results of the analyses on the raw data will be reported. In light of the fact that the serial accuracy and the absolute accuracy results were very similar, the serial accuracy results will be reported unless otherwise noted.

A 2 (skill level) X 2 (condition) X 3 (trial) ANOVA with repeated measures on the second and third factors was conducted for the purpose of determining whether the presence of context had an affect on recall performance, and whether this effect was dependent upon skill level. While each segment in the breakdown trial represented movement in only one direction, each kata had a different number of segments. Thus, the scores were collapsed across segments in order to create an overall measurement of accuracy. For the serial accuracy analysis, there were main effects of Group, $\underline{F}(1,18)= 5.80$, $p<.05$, $\underline{MSe}=1807.73$, and Trial, $\underline{F}(2,36)= 55.63$, $p<.001$, $\underline{MSe}= 202.11$, and a Group - by - Condition - by - Trial interaction, $\underline{F}(2,36)=3.63$, $p<.05$, $\underline{MSe}= 188.14$. Tukey LSD post hocs showed that the novice group with context on the first recall trial created the three-way interaction that is illustrated in Figure 1. Specifically, the differential effect of group across condition and recall trials was elicited by the significantly inferior performance of this condition in comparison to all others. Experts and novices, both with and without context, significantly improved their recall performance from the first whole trial to the breakdown trial. Serial recall was maintained by both groups, regardless of condition, for the second whole recall trial following the breakdown. A final observation to note in this analysis is the fact that the expert group's recall performance was always superior to the novice's, with the exception of the second whole recall trial with context.

A pre-posttest design was created in order to evaluate the effects of the breakdown trial on recall accuracy. That is, a 2 (skill level) X 2 (condition) X 2 (trial) ANOVA with repeated measures on the last two factors was performed to assess accuracy on the first and third recall trial where the entire kata was demonstrated. A main effect of Group, $\underline{F}(1,18)= 5.12$, $p<.05$, $\underline{MSe}= 1553.46$, revealed that the expert group was more accurate than the novice group. The Trial effect, $\underline{F}(1,18)= 65.69$, $p<.001$, $\underline{MSe}= 227.38$, indicated that there was a

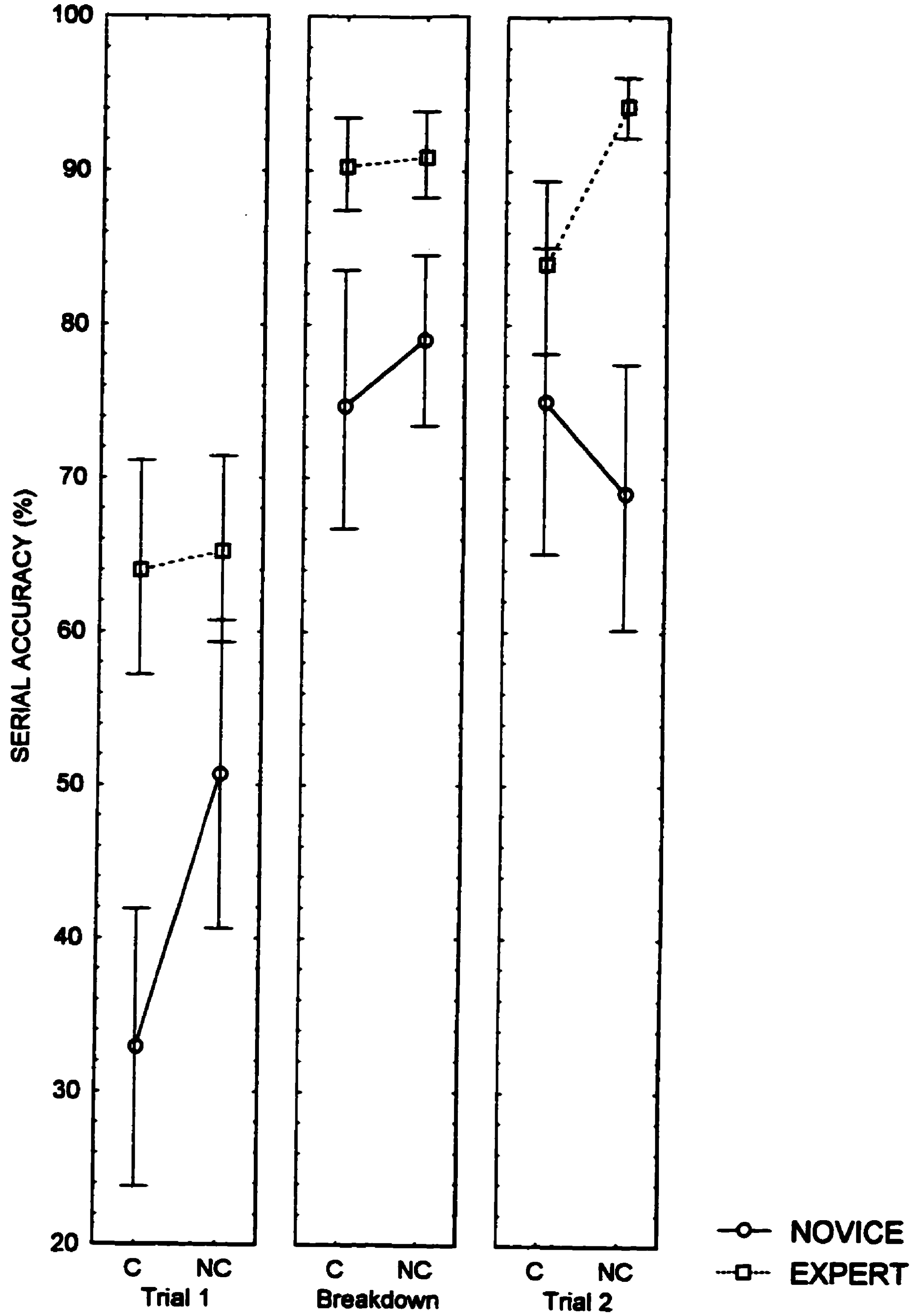

Figure 1. Group X Condition X Trial Interaction with Breakdown

significant improvement in recall performance between the first and second trials. Post hoc comparisons of the Group - by - Condition - by - Trial interaction, $F(1,18) = 5.93$, $p < .05$, $MSe = 226.80$, convey a number of points of interest. First, both groups improved significantly from the first trial to the second, regardless of condition. Second, on the first trial the novice group was less accurate with context than without. Third, by the second trial the novice group with context reached the level of the novice group without context. Fourth, expert recall was always superior to the novice, except for the second trial with context. It was in this analysis that the transformed serial position data made a difference. Where the raw analysis reported a non-significant difference in recall for the expert groups on the second trial, the transformed analysis showed that the experts were more accurate in the absence of context. The untransformed three-way interaction is illustrated in Figure 2.

A 2 (skill level) X 3 (trial) ANOVA with repeated measures on the second factor was conducted on the no context data for the purpose of determining whether adding a trial with context after two without context influenced recall. Higher serial recall by the experts was evidenced by the main effect of Group, $F(1,18) = 5.59$, $p < .05$, $MSe = 1203.91$. An effect of Trial, $F(2,36) = 28.00$, $p < .01$, $MSe = 132.83$, was also observed. Post hoc analyses showed that the first trial without context was less accurate than the second trial without context and the third trial with context, while recall for the second and third trials was similar. The means for the serial accuracy data are found in Table 2.

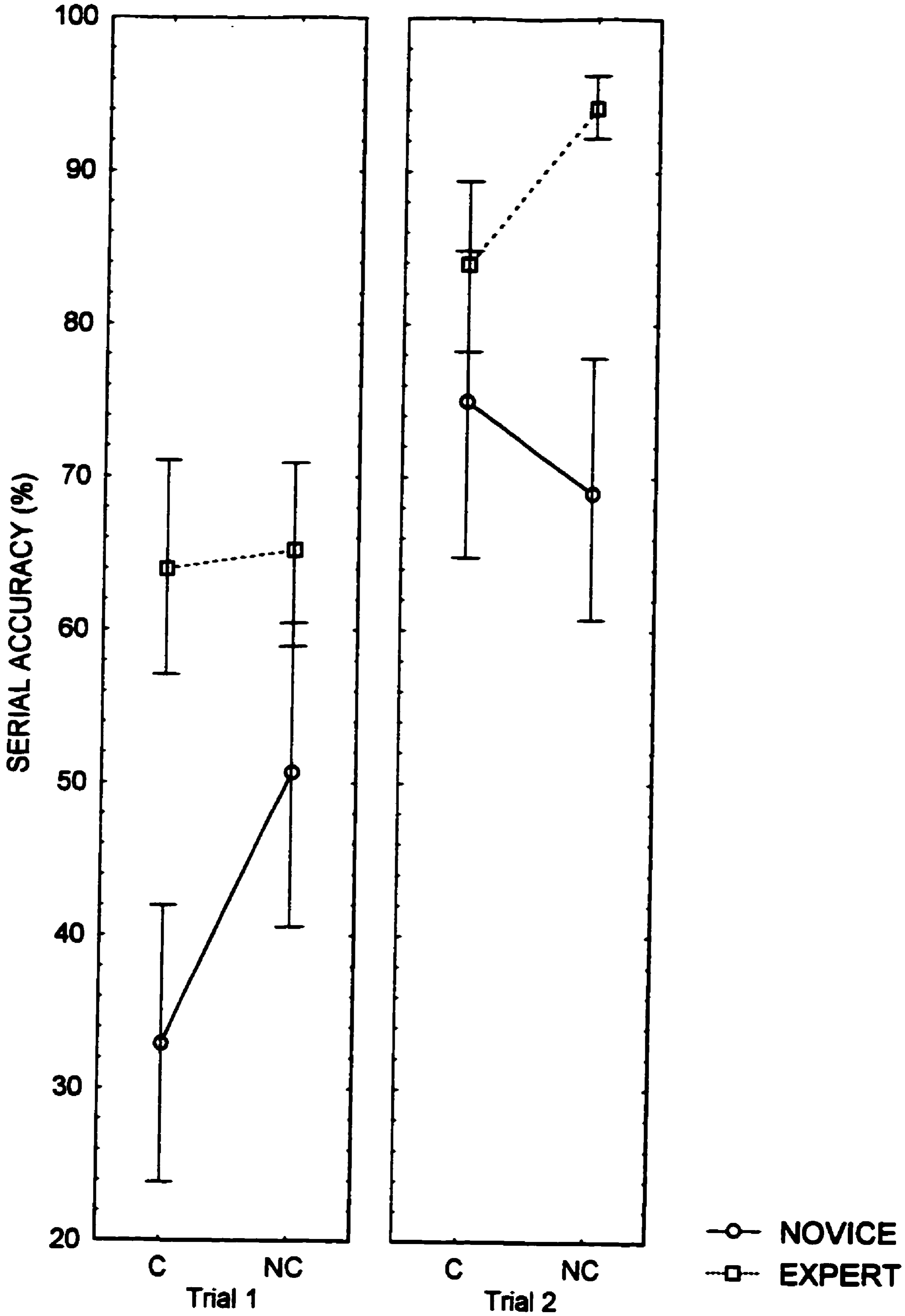

Figure 2. Group X Condition X Trial Interaction

TABLE 2. CONTEXT - NO CONTEXT EXPERIMENT
MEAN VALUES FOR SERIAL ACCURACY (%) WITH THE ADDITION OF CONTEXT

VARIABLE				LEVEL OF SIGNIFICANCE
GROUP	NOVICE 63.0	EXPERT 84.4		p<.05
TRIAL	1 58.0	2 81.6	3 (context) 81.5	p<.001

Experiment 2: Structured - Unstructured Analysis.

The purpose of this analysis was to determine whether skilled memory performance in the martial arts was conditional upon skill level and structured, domain-specific information. All variables were normally distributed. Due to the similarities between the serial and absolute accuracy results, the serial accuracy analyses will be reported unless otherwise noted.

A 2 (skill level) X 2 (structure) analysis of variance (ANOVA) with repeated measures on the second factor was conducted to ascertain whether the typical skill-by-structure interaction was evident in this experiment. In addition to significant main effects for Group, $\underline{F}(1,18)= 4.85$, $p<.05$, $\underline{MSe}= 714.47$, and Structure, $\underline{F}(1,18)= 23.10$, $p<.001$, $\underline{MSe}= 219.05$, Tukey LSD post hoc analysis on the interaction, $\underline{F}(1,18)= 4.28$, $p<.05$, $\underline{MSe}= 219.05$, confirmed that the expert's performance was superior to the novice's for the structured sequences. The interaction is presented in Figure 3. Performance by the

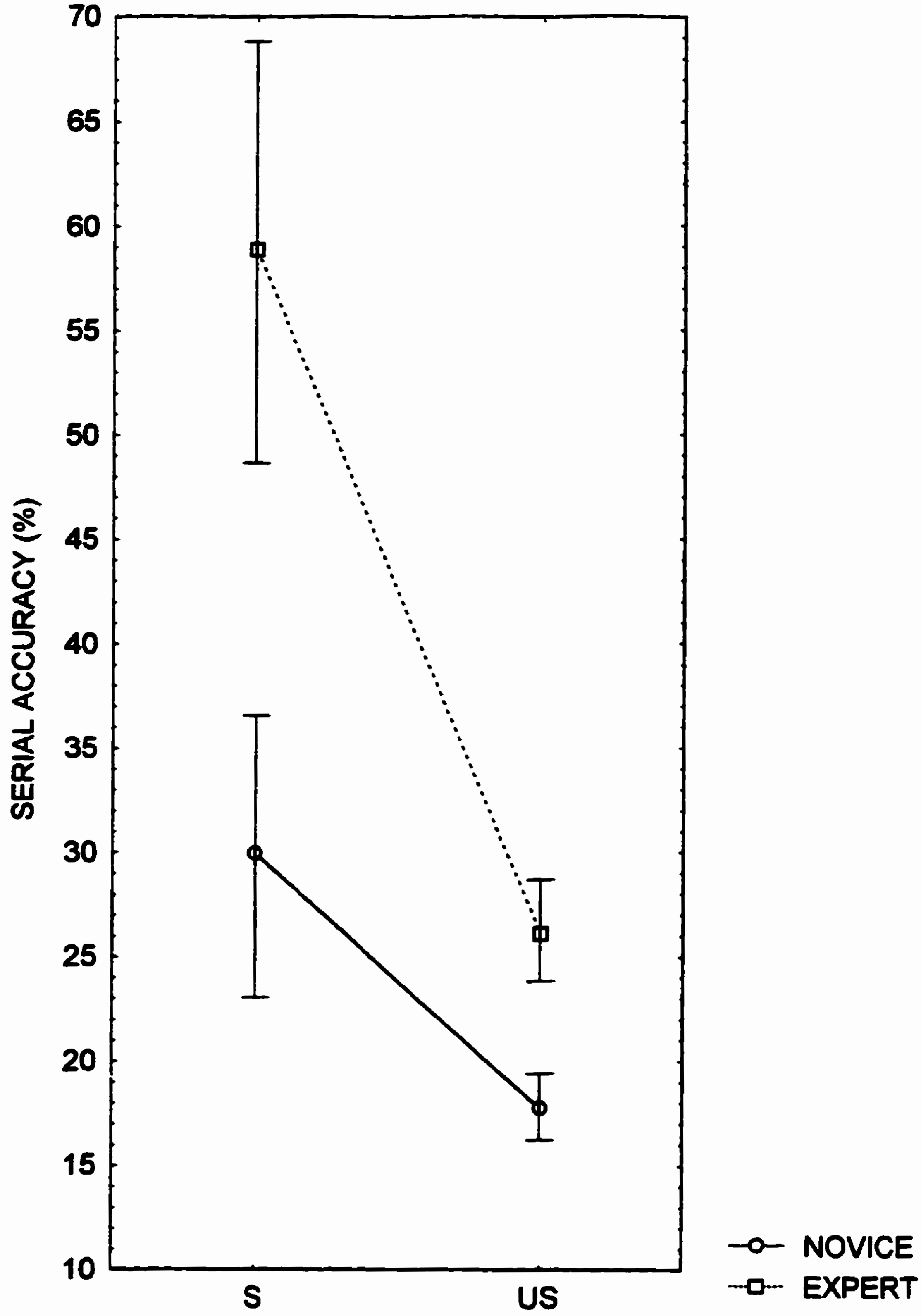

Figure 3. Group X Structure Interaction

novice group was not differentially affected by the quality of information, while the expert group's performance was significantly less accurate for the unstructured kata. Main effects of Group, $F(1,18)=6.16$, $p<.05$, $MSe=394.24$, and Structure, $F(1,18)=162.60$, $p<.001$, $MSe=119.83$, were also observed in the absolute accuracy analysis, however the Group-by-Structure interaction was not significant.

Deliberate Practice Questionnaire.

Activity Ratings

Independent t-tests with Bonferroni adjustments revealed that experts and novices had similar views regarding the relevance, effort, enjoyment, and concentration associated with the thirty-one activities that were listed in the questionnaire. Therefore, the rating data were collapsed across both groups. The collapsed means for concentration, effort, enjoyment, and relevance are illustrated in Table 3. The means that were significantly higher than the grand mean for that particular dimension are represented by a superscript "H", while those that were significantly lower than the grand mean have an "L". Significant differences were determined with dependent t-tests that had a Bonferroni adjustment applied ($p<.05/31=.0016$).

Practice With Others

Sparring, group classes, kata training, and impact training were activities that received significantly high ratings for all four dimensions. Flexibility training

TABLE 3
MEAN VALUES FOR CONCENTRATION, EFFORT, ENJOYMENT, and RELEVANCE

Mean concentration, effort, enjoyment, and relevance ratings, collapsed across expert and novice groups. Bonferroni's adjustment was used to determine which activities were significantly higher (H) or lower (L) than the grand mean ($p \leq .0016$).

	Concentration	Effort	Enjoyment	Relevance
Practice With Others	GM=6.54	GM=6.56	GM=6.66	GM=6.70
sparring	8.65^{H}	8.95^{H}	8.55^{H}	8.85^{H}
weight training	6.74	8.16	6.28	6.11
jogging	4.70	7.20	3.65^{L}	5.05
flexibility training	8.55^{H}	9.00^{H}	7.10	9.00
swimming	5.05	5.70	5.70	3.50^{L}
cycling	4.95	6.05	7.25	4.35
group classes	9.30^{H}	9.05^{H}	9.35^{H}	9.80^{H}
kata training	9.45^{H}	8.85^{H}	8.55^{H}	9.50^{H}
impact training	8.26^{H}	9.00^{H}	8.74^{H}	9.26^{H}
Practice Alone				
weight training	7.25	8.20	6.11	6.95
flexibility training	7.95	8.80^{H}	6.55	8.45^{H}
jogging	4.85	6.55	3.65	4.90
alone with instructor	8.35	8.00	8.11	7.45
videos	4.73	1.63^{L}	5.32	4.58
swimming	4.75	5.50	5.30	3.30^{L}
cycling	6.05	6.60	7.95	5.35
kata training	9.15^{H}	9.05^{H}	8.80^{H}	9.30^{H}
bag training	7.84	8.42	7.63	7.37
Related to Karate				
diet/nutrition	6.00	5.65	4.45	7.75
training journal	4.90	4.65	3.05^{L}	5.55
watch karate	5.15	3.45^{L}	6.30	6.15
read karate theory	5.60	3.60^{L}	4.85	5.65
instruct	8.30	7.65	7.75	8.55
professional conversation	6.16	4.79	6.26	6.74
mental rehearsal	7.42	6.42	6.32	7.32
seminars	7.35	7.45	7.95	7.60
Unrelated to Karate				
sleep	2.05^{L}	2.05^{L}	8.90^{H}	8.70
school	8.30	6.05	6.05	6.35
active leisure	6.06	7.06	8.89^{H}	7.32
work	5.84	7.22	4.78	3.63^{L}
nonactive leisure	2.88^{L}	2.50^{L}	6.38	3.31^{L}

received high ratings for both concentration and effort. Jogging received a rating significantly lower than the grand mean for enjoyment, while swimming was rated lower for relevance.

Practice Alone

Kata training was rated significantly higher than the overall mean on all four dimensions. Flexibility training received a significantly higher rating for both effort and relevance. Watching karate videos was lower than the grand mean for physical effort, while swimming was deemed irrelevant to karate performance.

Activities Related to Karate

There were not any activities rated significantly higher than the overall mean for relevance, enjoyment, effort, or concentration. Keeping a training journal was rated significantly lower for enjoyment. Both watching karate and reading karate theory received ratings that were significantly lower than the grand mean for physical effort.

Everyday Activities (Unrelated to Karate)

Sleep and active leisure were both rated significantly higher than the overall mean for enjoyment. Nonactive leisure was significantly lower than the grand mean for concentration, effort, and relevance. Work was deemed irrelevant, while sleep received significantly lower ratings for concentration and effort.

A Spearman correlation analysis was conducted to assess the interrelationships between the four dimensions for all of the activities related to karate. Results showed that relevance was most highly correlated with concentration ($r=.92$, $n=26$, $p<.001$), however it was also significantly related to effort ($r=.77$, $n=26$, $p<.001$), and enjoyment ($r=.72$, $n=26$, $p<.001$). Concentration was highly correlated with both effort ($r=.82$, $n=26$, $p<.001$), and enjoyment ($r=84$, $n=26$, $p<.001$), while the relationship between effort and enjoyment was also significant ($r=.73$, $n=26$, $p<.001$).

Retrospective Time Estimates

An independent t-test, $t(18)=.98$, $p>.34$, reported that experts and novices were very similar, considering the total number of hours they spent per week participating in all of the karate-related activities (i.e. practice alone, practice with others, karate-related activities)(novice, M=35.3 hrs/week; expert, M=27.6 hrs/week). A second independent t-test, $t(18)=-.36$, $p>.72$, was performed to ascertain whether the two groups were spending differential amounts of time engaged in the most relevant activities during the first year of their martial arts careers (novice, M=12.8 hrs/week; expert, M=13.7). Of the thirty-one activities provided, sparring, group classes, impact training, flexibility training alone, and kata training alone and with others, were considered most relevant to martial arts performance. The absence of a Group effect indicated that both groups were spending similar amounts of time engaged in highly relevant activities. Expressed as a percentage of total time, the novice and expert groups spent 36% and 50%, respectively, of their time engaged in those activities deemed most relevant.

A one-way ANOVA with repeated measures (first year, third year, black belt year, most recent year) was conducted to determine whether the total amount of time spent per week in all activities related to karate changed as a function of year. Since one subject's black belt year and most recent year were not mutually exclusive, the average time spent during the most recent year of participation is representative of only nine subjects. Tukey LSD post hocs of the main effect of Year, $F(3,27)=8.41$, $p<.001$, $MSe=188.11$, indicated a steady increase in time devoted to karate-related activities until the year that the experts received their black belt (first year, M=27.6 hrs/week; third year, M=41.4 hrs/week; black belt year, M=58.0 hrs/week). A decrease in participation in these activities was observed between the black belt year and most recent year of participation (M=46.1 hrs/week), however this difference did not reach the conventional levels of significance ($p=.064$).

A one-way ANOVA on year was conducted to assess whether the number of hours spent per week in highly relevant activities was influenced by the specific year of the expert's career. Post hoc analyses of the Year effect, $F(3,27)=3.48$, $p<.05$, $MSe=76.72$, reported a significant increase in time spent from the third year to the year that the student received his/her black belt (third year, M=19.0; black belt year, M=26.2). Once again, the decrease in time spent between the black belt year (M=18.3) and most recent year approached conventional levels of significance ($p=.054$). For the first, third, and black belt year, participation in the six significantly relevant activities comprised 50%, 46%, and 45%, respectively, of the total time engaged in karate-related activities. For the most recent year of involvement, 40% of the expert's total time was comprised of these highly relevant activities.

Discussion

Context-No Context Recall.

Similar to other closed-skill athletes such as ballet dancers and figure skaters, martial artists must learn a required programme of elements and sequences in order to advance through various belt classifications. One can assume that the higher the belt level, the more techniques and complex sequences within the student's repertoire. Essentially, each kata represents a combination of techniques that are used to ward-off imaginary attackers. The kata are symmetrical, meaning that the techniques used against the attacker to the right are then repeated when battling an attacker who is coming from the left. An important part of determining success in the martial arts is the ability of the student to commit these prescribed kata to memory. In accordance, a large portion of class time is devoted to studying novel techniques and kata.

A strategy often used by martial arts instructors is to provide a verbal context when demonstrating novel kata to their students. Intuitively such a strategy makes sense, since the structure inherent in the sequence of techniques is elaborated upon. As a result of this attempt to make the sequence more meaningful, instructors expect that performance will be enhanced when their students are later required to replicate the sequence.

The present investigation represents the first attempt to determine whether an accompanying context is effective in improving recall of novel motor sequences. Recall that the cognitive literature has proposed that a mnemonic aid, whether it be music or verbal elaboration, paired with target information at encoding can prove beneficial at recall (Chase & Ericsson, 1981; Chazin & Neuschatz, 1990; Helstrup, 1993; Scruggs & Brigham, 1991; Wallace, 1994). Thus, it was hypothesized that a verbal context may be valuable as a mnemonic aid for the novice karate students at encoding. Findings similar to Wallace (1994) concerning an interference effect on the first recall trial were obtained in the present study. This was evidenced by the fact that the novices with context recalled significantly less than the novices who observed a demonstration of the sequence without context (context, M=32.9%; no context, M=50.7%). These results suggest that the increased recall demands due to the initial presence of context caused a performance decrement for the novices (Magill, 1984; Wallace, 1994).

Unlike previous findings in the cognitive domain (Helstrup, 1993; Wallace, 1994), a benefit of context on following trials was not observed in this study. A nonsignificant condition-by-trial interaction did not support past findings in the music literature. These results suggest that the strategy of providing a verbal context while demonstrating novel movement information is of no benefit to the learner. The added verbal information only served to hinder performance on the initial trial for the novice group, despite the fact that most of the novices believed that the accompanying context benefited their recall performance.

Helstrup (1993) hypothesized that explicitly providing a context or mnemonic strategy for the subjects may allow them to concentrate more on the target information. Like a melody accompanying textual information, perhaps a verbal commentary paired with motor information would enhance the meaning of the sequences by chunking elements and putting specific constraints on the number of possible responses. It was anticipated that the context accompanying the motor cues would serve as a retrieval device that would 'trigger' the technique that accompanied the appropriate location in the context, especially since the context was repetitive (Wallace, 1994). To the contrary, serial recall did not benefit from the presence of context in this study, thus providing no support for the use of such an instructional strategy in the martial arts.

It is suggested that the absence of a three-way interaction for the absolute accuracy analysis indicates the leniency of the test in comparison to the measurement of serial accuracy. These results may lead one to erroneously conclude that it does not matter whether a context is initially provided for the novices. It should be noted that success in the martial arts places much greater emphasis on serial, as opposed to absolute recall accuracy. Techniques are considered incorrect if they are not executed in the same serial order that they were demonstrated, despite the fact that all of the correct movements may have been recalled. Considering the results of the serial accuracy analysis, if novel sequences are only demonstrated one time with context for the novice student, his/her performance will most likely suffer.

For the present study, it was expected that the black-belt students would recall more accurately than their novice counterparts. It was also anticipated that their performance would not be differentially affected by the presence of context, since it is feasible that they were able to generate their own internal context when one was not provided for them. This notion was supported since the expert's performance was similar, regardless of condition. Similar to other closed-skill performers, both cognitive (Chase & Ericsson, 1981; Ericsson & Polson, 1988) and motor (Bedon & Howard, 1992; Deakin & Allard, 1991; Edmonstone, 1987; Starkes et al., 1987), the expert martial artist derived an advantage through recognition of the meaning inherent in the structured kata.

An interesting finding from the transformed analyses that was not evident in the raw data was that the expert group's performance suffered on the second recall trial in the presence of context. Two interpretations of this observation are possible. First, perhaps the context provided by the demonstrator created some sort of interference effect by the second recall trial. Second, it is possible that in the absence of an externally-provided context, the internally-generated context of the expert was more meaningful. As was postulated by Helstrup (1993), perhaps contexts that are created by the individuals themselves carry more meaning. However, it is not known if the subjects attempted to implement the context that was provided for them, or if they ignored the additional information in order to generate a context that was more congruent with the target information.

It was not expected that an advantage of context would be observed on a final recall trial for the kata that were initially demonstrated without context. A new piece of information had been introduced to the individual, and it was believed that it would not prove beneficial until it was integrated with the motor information (Magill, 1984). Also, it was reasonable to assume that all subjects would have already attempted to generate and integrate their own context by the second recall trial. Support for this assumption was evidenced by the fact that, for both experts and novices, recall from the second whole trial without context did not differ from the final recall trial that included context (novice trial 2, M=69.0%; novice context, M=69.3%; expert trial 2, M=94.2%; expert context, M=93.8%).

Another strategy often implemented by martial arts instructors is to provide an entire demonstration of a novel sequence, and then divide the elements of the kata into functional units (i.e. techniques including movement in one direction). By breaking-down the sequence, it is plausible that recall should be facilitated due to a decreased memory load for each segment. The present investigation attempted to determine whether dividing the kata into segments would benefit subsequent recall of the entire sequence.

While it was hypothesized that the breakdown trial would enhance recall accuracy, it was also postulated that a more favourable memory load would be conducive to further integration of the context with the movement information. Complete integration may allow the contextual information to serve as both a mnemonic strategy for encoding purposes and as a retrieval device for subsequent recall of the entire sequence. As anticipated, recall performance for both groups and conditions improved significantly from the first recall trial to the breakdown trial. Evidence of sufficient integration and subsequent benefit of context would have been provided if the context condition's performance improved or was maintained following the breakdown, while the performance of the no-context condition suffered since it could not rely on the context for retrieval of the entire kata. The results of the present investigation did not support this notion. Serial recall performance on the second whole trial after the breakdown was maintained by both groups, and there was not a significant difference between the context and no context conditions (with the exception of the transformed serial accuracy analysis). Thus, an external context did not provide the novices with an advantage since it did not act as a retrieval 'hook' to improve serial recall.

An important observation that was made in this analysis was the beneficial effect that the breakdown trial had on serial recall. The reduction in memory load was conducive to further encoding of the techniques, which was reflected in the maintenance of recall on the following trial, regardless of condition. These results offer support for employing such a strategy when demonstrating novel motor sequences to experts and novices

<u>Structured-Unstructured Recall</u>.

The skill-by-structure interaction observed in the present study provided further support for the notion that exceptional recall is not an artifact of superior memory capacity. It is inferred that the selective display of skilled memory for structured information is a function of a domain-specific knowledge base. Since the expert and novice martial arts students recalled the same amount of information for unstructured sequences (kata), it can be suggested that it was the lack of meaningful associations found in the choreographed kata that brought the expert back to the performance level of the novice.

The most robust observation in expertise research has been the characteristic skill-by-structure interaction. Cognitive experts (Chase & Simon, 1973; Chase & Ericsson, 1981; de Groot, 1965; Egan & Schwartz, 1979; Engle & Bukstel, 1978) and motor experts (Allard et al., 1980; Deakin & Allard, 1991; Edmonstone, 1987; Garland & Barry, 1991; Starkes et al., 1987; Starkes, 1987; Williams et al., 1995) display exceptional recall for domain-specific information only. When the structured information is removed from the schematic diagram or demonstrated sequence of elements, this superiority is erased and the expert performs with an average STM capacity (Miller, 1965).

For structured kata, it is suggested that the experts have developed the ability to 'see' the meaningful information in the kata and commit it to LTM. Since the random kata did not contain the same degree of meaning, the experts were unable to rely on their elaborate knowledge for sequentially dependent techniques. While not a representative paradigm, the structured-unstructured recall results are useful when dealing with the context-no context experiment, since a hardware explanation cannot be used to account for superior recall by the black-belt students.

Deliberate Practice.

The present investigation did not find any activities that fit Ericsson et al.'s (1993) original definition of deliberate practice. Nevertheless, similar to the research conducted with the musicians (Ericsson et al., 1993), figure skaters (Starkes et al., 1996b), and wrestlers (Hodges & Starkes, 1996), the requirement of high concentration, high relevance was strongly supported by the martial artists in this study. That is, the activities considered highly relevant to their karate performance (sparring, class, impact training, kata training with others and alone) also received significantly high ratings for concentration. The only exception was flexibility training alone, which received a high rating for relevance, but was not significantly higher than the grand mean for concentration. It should be noted, however that this score was higher than the overall mean (flexibility training alone, M=7.95; grand mean, M=6.54).

Conversely, this study provided no support for Ericsson et al.'s (1993) requirement of highly relevant activities receiving significantly lower ratings for enjoyment. Martial artists were once again comparable to other athletes in that they enjoy engaging in the activities that they believe are most relevant to improving their performance. With the exception of flexibility training alone, which was not significantly lower than the grand mean for enjoyment (flexibility training alone, M=6.55; grand mean, M=6.66), all of the activities deemed highly relevant also received significantly high ratings for enjoyment. The original research conducted by Ericsson et al. (1993) with musicians considered practicing alone to be the only activity that displayed the required characteristics. That is, highly effortful (concentration for the athletes), highly relevant, but not inherently enjoyable. One must question whether practicing alone actually satisfied Ericsson et al.'s (1993) requirements, since their musicians rated this activity higher than the grand mean for pleasure (practice alone, M= 7.23; grand mean, M=6.52).

The Spearman rank correlation analysis for the karate related activities revealed some points of interest. For example, the relationship between concentration and relevance (.92) for martial artists was the highest. The research conducted with musicians (.75), skaters (.90), and wrestlers (.83) also reported that the correlation between concentration (effort for musicians) and relevance was the strongest. For both martial artists and wrestlers, there were also significant correlations between relevance and physical effort (.77 and .68, respectively), relevance and enjoyment (.72 and .59, respectively), and concentration and enjoyment (.84 and .64, respectively). Contrary to past findings, the present investigation also reported significant correlations between enjoyment and effort (.73) and concentration and effort (.82).

The strong positive correlation between concentration and relevance is a very interesting observation for the athletes given the obvious physical nature of their domain. For the present study, these results should be interpreted with caution for two reasons: First, there was also a strong relationship between effort and relevance, so the importance of the physical aspect of practice should not be down-played. Second, unlike previous studies this investigation reported a significant correlation between concentration and effort. One must question whether the same underlying construct was being measured when the martial artists rated on these two dimensions, since they may not have been differentiating between the two. From these observations one cannot be sure whether physical effort or concentration is more important when defining deliberate practice in the martial arts.

Another point of convergence between present and past research across domains was the nature of the tasks that were considered most relevant. Specifically, the practice activities rated as most important were those that were the most closely related to what the musician or athlete does during an actual performance. Taking classes and kata training with others were considered the two most relevant activities by the karate students. Similarly, mat work and working with a coach were the two most relevant activities for wrestlers (Hodges & Starkes, 1996); lessons with a coach and on-ice training received the highest rating for figure skaters (Starkes et al., 1996b); practice alone and lessons were deemed most important for the musicians (Ericsson et al., 1993). Considering the statistically significant relevant activities in this study, sparring, kata training, impact training, and some group class activities are closely related to competition (sparring and kata competitions), whereas specific class activities and kata training are closely related to belt examinations.

In contrast with past research was the finding that working alone with a mentor was not considered to be a particularly relevant activity in the martial arts. Perhaps this is not so surprising, since five experts and three novices reported that they had not spent any time alone with an instructor during their first year of participation. Furthermore, three black belt subjects did not receive any private lessons prior to the year they graded for their black belt, while one expert reported that he had never received any private instruction. Contrary to the emphasis that other sports such as figure skating place on private lessons, it is apparent from this study that martial artists believe there is more to gain through participation in group lessons.

The retrospective time estimates from the present study demonstrated that the expert and novice groups were spending similar amounts of time engaged in all karate-related activities at the beginning of their careers (novice, M=35.3 hours/wk; expert, M=27.6 hours/wk). These results coincide with previous deliberate practice research with athletes and musicians (Ericsson et al., 1993; Starkes et al., 1996b). Furthermore, both groups were spending similar amounts of time in the activities that were considered most relevant (novice, M=12.8 hours/wk; expert, M=13.7 hours/wk).

Due to the fact that karate students typically grade for two or three belts a year, it was impossible to control for years of involvement between the expert and novice groups. Thus, between-group comparisons beyond the first year of participation were precluded given the short period of time that the novice group had been involved in the martial arts. Nonetheless, some important observations were made regarding the changes in the practice characteristics of the black belt subjects as a function of time.

Similar to previous findings, there was a steady increase in the estimates of time that the martial artists participated in all of the activities related to karate as they advanced through their belt classifications (first year, M=27.6 hours/wk; 3rd year, M=41.4 hours/wk; black belt year, M=58.0 hours/wk). After subjects successfully graded for their black belt, a drop-off of approximately twelve hours per week was reported for their most recent year of involvement (M=46.1 hours/wk). Reports of a decrease in participation are not readily apparent from previous research. It is suggested that this decrease in practice time was due to the expert group 'relaxing' somewhat after intensely preparing to grade for their black belt, which represented a long-term goal that they had set for themselves.

The year that the experts achieved their black belt marked a peak in the number of hours that they were spending each week in all activities related to karate (58.0 hours/wk). Ericsson et al.'s (1993) diary data revealed that their violinists and pianists were spending 50.6 and 56.8 hours per week, respectively, engaged in all activities related to music, while Hodges and Starkes' (1996) international wrestlers estimated spending approximately 46 hours each week in all wrestling-related activities. Figure skaters, however, practiced 28.9 hours each week (Starkes et al., 1996b). This difference was thought to reflect the financial implications of on-ice practice; the fact that this time discrepancy was not made-up through off-ice training provides further support for the argument that the most relevant activities are those that are the most closely-related to what the individual does during a performance. If the same benefit could be attained through off-ice practice activities, perhaps the difference between the skaters and other athletes would have been smaller (Starkes et al., 1996b).

It appears that the black belt year for the expert group was quite close to the musicians' most recent year. Unfortunately, one cannot be certain as to how accurate the subjects were at estimating the amount of time that they spent practicing, since no reliability checks were implemented. Nine of ten experts received their black belt prior to their most recent year of involvement. Analysis of their most recent year reported a decrease in time spent in highly relevant activities, so even if a diary had been included as a measure of reliability, it is suggested that it would not have been appropriate to compare the martial artist's most recent week with the research conducted in other domains.

One of the difficulties arising from an attempt to compare the amount of time spent in deliberate practice across domains is due to the fact that researchers have counted deliberate practice differently. For the present investigation, the activities considered to most accurately encompass deliberate practice were those that received the highest ratings for relevance (i.e. sparring, group classes, kata training with others, impact training, flexibility training alone, and kata training alone). Recall that these activities (with the exception of flexibility training alone) were also rated significantly high on the concentration dimension, which satisfies the second prerequisite of Ericsson et al.'s (1993) initial definition of deliberate practice. Obviously, the third tenet of the original theory (i.e. significantly low on enjoyment) could not be fulfilled if the first two were. Practice alone was thought to be the only deliberate practice activity for Ericsson et al.'s (1993) musicians. All of the 'practice alone' and 'practice with others' activities were considered deliberate practice for the skaters and wrestlers, respectively (Starkes et al., 1996b). Estimates of the total time spent in these activities each week for the expert's black belt year was 26.2 hours each week. This estimate is quite similar to the estimates from the research conducted in other domains, despite the fact that the deliberate practice activities for martial artists were determined differently. Perhaps this time range represents an optimal number of deliberate practice hours across different domains. Regardless of the type of activities counted as deliberate practice, it is intriguing that the estimates of the martial artist's black belt year (M=26.2 hours/wk) were very similar to other domains concerning the number of hours per week spent in these activities during their most recent year of participation (violinists, M=29.8 hours/wk; pianists, M=26.7 hours/wk; skaters, M=22.2 hours/wk; wrestlers, M=19.1 hours/wk).

The changes in hours per week spent in deliberate practice activities show a similar pattern compared to the total time spent in all activities related to karate. That is, from the first year of participation to the year they received their black belt, the students steadily increased the absolute number of hours they devoted to highly relevant activities (1st year, M=13.7 hours/wk; 3rd year, M=19.0 hours/wk; black belt year, 26.2 hours/wk). Once again following their black belt year, students decreased the amount of time they devoted to these activities (most recent year, M=18.3 hours/wk).

The relative amount of time martial artists engaged in deliberate practice was very similar to performers in other domains. For example, the students estimated that they were devoting approximately 45% of their total karate-related time to significantly relevant activities the year they achieved their black belt. From their first year to their most recent year, this percentage ranged from 50% to 40% of their total estimated time. Violinists spent 48%, pianists spent 47%, and wrestlers spent 42% of their total time engaged in those activities that were considered deliberate practice (Ericsson et al., 1993; Hodges & Starkes, 1996). Conversely, figure skaters spent 77% of their total time in deliberate practice activities (Starkes et al., 1996b). For skaters, off-ice training is not as beneficial, so they simply do not engage in those activities. Since it was on-ice time that was counted as deliberate practice, this was reflected in the relatively large percentage of time engaged in deliberate practice.

Looking more specifically at the activities that were considered deliberate practice in the present study, both practice with others (sparring, kata training, classes, impact training) and practice alone (kata training, flexibility training) were represented. An important point to make here is that the changes observed in deliberate practice across time were mainly due to the increase in time devoted to relevant activities with others (1st year, M=9.7 hours/wk; 3rd year, M=13.7 hours/wk, black belt year, M=21.0 hours/wk; most recent year, M=10.7 hours/wk). In fact, the time spent practicing relevant activities alone did not change significantly over the martial artist's career (1st year, M=4.0 hours/wk; 3rd year, M=5.3 hours/wk; black belt year, M=6.2 hours/wk; most recent year, M=3.6 hours/wk). A main effect of Activity (alone, with others) was of no surprise, since there were only two relevant activities practiced alone, whereas practice with others was represented by four. It was the interaction between these two types of practice activities across time that was unexpected. This suggests that from the beginning of the student's career, a specific level of kata training and flexibility training alone was identified and maintained, while advancement through belts and participation in competitions signified an essential increase in relevant practice with others. If the importance of the activities considered deliberate practice is reflected in the amount of time spent in these activities, results of this study suggest that the importance of highly relevant activities practiced with others increases as the martial artist becomes more proficient.

Conclusions

The Influence of Context on the Acquisition of Novel Motor Sequences.

This study did not provide any support for the strategy of pairing a verbal context with motor information when demonstrating novel sequences to martial artists. The only effect that the verbal context had on performance was to hinder the novice group's recall on the first trial. Further, transformed analyses indicated that the expert group's performance was hindered in the presence of context on it's second recall attempt.

Future investigations attempting to determine the role of context when recalling movement information should address the following issue that arose from this research: By the second whole trial the novice group was only recalling at 75% and 70% serial accuracy with context and without, respectively. If the present design had allotted for the measurement of trials to 100% accuracy, more definitive conclusions concerning the role of context in the acquisition of motor sequences could be drawn.

Regardless of whether context was present, an important observation was the benefit that dividing the sequence into shorter segments had in improving both group's recall performance. The demonstration of the whole sequence in a series of shorter segments was effective in significantly improving recall performance which was maintained for the following recall trial. Thus, the results of the present study lend support for this instructional strategy when demonstrating novel sequences to students, regardless of their belt classification.

Deliberate Practice and Expert Performance.

The present investigation did not find any martial arts activities that conformed to all of the tenets of the initial theory of deliberate practice. However, similarities emerged concerning the types of activities that experts in different domains considered most relevant to their performance. The activities that were most closely related to the actual performance were those that received the highest ratings for relevance by musicians and athletes. Unlike Ericsson et al. (1993), research with athletes, including martial artists, has supported the notion that practice with others is important for gains in performance. This study also replicated previous findings in the athletic domain regarding the positive relationship between physical effort and relevance, and enjoyment and relevance. Further, the strong positive correlation between concentration and relevance was similar to previous findings. One area where the martial artists diverged from the previous deliberate practice research with athletes was the lack of differentiation between physical effort and concentration.

The results of the present investigation converged with past research regarding the number of hours spent each week in deliberate practice. Through comparison of the martial artists' black belt year with the most recent year of participation of previous expert groups, it appears that there may be an optimal number of hours in which exceptional performers engage in deliberate practice.

Finally, by dividing the relevant practice activities into practice with others and practice alone, it was observed that the experts significantly increased the time they spent practicing with others, while time spent practicing alone was maintained over the course of their careers. This is thought to indicate the increased importance of practice with others as one progresses through the martial arts classification system.

Future investigations attempting to determine the role of deliberate practice in expert performance should consider the following issues that were evident in this investigation: Since between-group comparisons were not made beyond the first year of participation in this study, inferences could not be made regarding the role that deliberate practice may play in the acquisition of martial arts expertise. Nonetheless, a number of comparisons with expert groups across domains were made. While expert-novice differences in time devoted to deliberate practice could not be established, previous research has consistently shown that activities constituting deliberate practice have differentiated skill levels from relatively early-on in their respective careers (Ericsson et al., 1993; Hodges & Starkes, 1996; Starkes et al., 1996b).

In addition, the present experiment did not employ a reliability check in order to determine the accuracy with which the subjects were estimating their time spent in specific activities. It is suggested that the most recent week of participation would not constitute an appropriate comparison with other domains, since the most recent year of participation for the martial artists represented a decrease in participation. Given that the year the martial artists attained their black belts represented a peak in time engaged in deliberate practice, perhaps future investigations should consider the achievement of specific goals (i.e. black belt) when measuring practice time at different points in their subject's careers.

Another issue concerns the cross-sectional design of the present study. A longitudinal design is ideal for deliberate practice research. By tracking individuals from the beginning of their careers until they attain a predetermined level of expertise, the limitations of relying on retrospective data would be eliminated. Typically, the diary data gathered from previous research has reflected a positive bias concerning the estimates of time spent in various activities. It is thought that this bias may represent an aspired to level of practice (Ericsson et al., 1993). Also, it is only through a longitudinal design that the precise role that deliberate practice plays in the development of expertise can be determined. Unfortunately, such a design is impractical due to the required sample size, the length of time that the participant's activities would have to be tracked, and the subsequent inconvenience experienced by the participants.

Investigations conducted in the athletic domain have been consistently unable to find any activities that fit Ericsson et al.'s (1993) strict definition of deliberate practice. As such, the type of activities that have been deemed 'deliberate practice' has differed for each investigation. Despite the fact that similarities have been reported from comparisons of time spent in deliberate practice across these domains, a working definition of *what* constitutes deliberate practice has not been realized. Ericsson et al. (1993) claimed that their theory was deliberately general so that it could be applied to other fields of expertise. The present research conducted with expert martial artists suggests that their framework is in need of revisions if it is to transfer across domains.

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APPENDIX A

CONSENT FORM

SCHOOL OF PHYSICAL AND HEALTH EDUCATION

Queen's University
Kingston, Canada
K7L 3N6

Dear Sir/Madam:

As a student of the Martial Arts Canada programme, you have been selected to participate in a study on expertise being conducted under the supervision of Dr. Janice M. Deakin, Associate Professor in the School of Physical and Health Education. Outlined below is a detailed description of the study.

PURPOSE:

The purpose of this study is to examine a memory skill within its naturally occurring context. Specifically, this study is an attempt to identify how martial arts students of varying skill levels go about learning new kata.

PROTOCOL:

Each subject will participate in two experiments which will be conducted during one session at the Martial Arts School. It is anticipated that the session will take approximately one hour.
During each experiment, subjects will observe a video demonstration of four kata by Sensei Coles. Following each demonstration, subjects will be asked to replicate the sequence that Sensei Coles has just performed. Each subject's performance will be videotaped for scoring following the experiment.
Subjects will be asked to complete a questionnaire which has been designed to provide information on the length of time they have been involved in martial arts, the amount of time per week they practice, and other information related to their involvement in this area.

IMPLICATIONS OF THE STUDY:

The results of this study will provide us with valuable information regarding expertise in the motor domain. More specifically, you will be giving us the opportunity to make an in-depth investigation of the underlying knowledge structures that influence skill development.
Practical application of the results of this work may assist in developing teaching and practice techniques that will enhance the speed of acquisition of skills within martial arts.

CONSENT FORM

Participation in this study is entirely voluntary, and individuals may choose to withdraw at any time. Following completion of this study, you may ask any further questions regarding the experiment. If you desire, you may receive the results of the experiment once it is completed. All data will be grouped for subsequent analysis, thereby protecting anonymity of individual subjects.

Any inquiries about the study may be directed to Thana Hodge at (613) 545-6000 (ext. 5725), Dr. Janice M. Deakin at (613) 545-6000 (ext. 4689), or Dr. Joan Stevenson (Director) at (613) 545-6000 (ext. 4687) at the School of Physical and Health Education, Queen's University, Kingston, Ontario.

I understand the above information and voluntarily consent to my child's participation in this study.

____________________, ____________________

Participant Participant's Age

____________________, ____________________

Parent/Guardian Date

APPENDIX B

KATA

Structured-Unstructured Experiment

Structured #1

1/4 turn left

L knifehand block
L palm block
L press block
L hook kick
L round kick
L side kick
R reverse punch

1/2 turn right

R knifehand block
R palm block
R press block
R hook kick
R round kick
R side kick
L reverse punch
L press block front
L hook kick
L round kick
R palm strike
R press block back
R hook kick
R round kick
L palm strike

1/2 turn front

L knifehand block
R palm strike

Unstructured #1

1/4 turn left

L high block
L lead punch
L side kick back

step forward
right front stance

R groin strike back

1/2 turn left

L lead punch
R side kick back
R back fist
L palm strike front
R groin strike back

Structured #2

step right horse stance

double low block
R side kick
R high block
L reverse punch
R low block
R back fist

step up to left

L side kick
L high block
R reverse punch
L low block
L back fist
double low block

Unstructured #2

1/4 turn left

L knifehand block

1/2 turn right

R lead punch
L punch to front
R front kick
R punch to back
R jump inverted side kick to front
L back kick & R palm strike
L front kick to back

Context-No Context Experiment

Kata #1

1/4 turn left

L lead punch
L front kick
R reverse punch

1/2 turn right

R lead punch
R front kick
L reverse punch

L side kick to front
R reverse punch

R side kick to front
L reverse punch

1/2 turn to front

L lead punch
L front kick
R reverse punch
R front kick

Kata #2

1/4 turn left

L high block
R reverse punch
R front kick
L reverse punch

right full turn

R high block
L reverse punch
L front kick
R reverse punch

1/4 turn front

L low block
R reverse punch
R front kick
L lead punch
R reverse punch

Kata #3

1/4 turn left

L press block
L back fist
L side kick
R reverse punch

1/2 turn right

R press block
R back fist
R side kick
L reverse punch

1/4 turn front

L knifehand block
L grab technique
L low round kick
L high round kick
R reverse punch

Kata #4

1/4 turn left

L low block
R reverse punch
L high block
R reverse punch
R front kick
L reverse punch
R lead punch

full right turn

R low block
L reverse punch
R high block
L reverse punch
L front kick
R reverse punch
L lead punch

1/4 turn front

L low block
R reverse punch
R side kick
R back fist

reverse full turn to back

R low block
L reverse punch
L side kick
L back fist

APPENDIX C

ANALYSIS OF VARIANCE TABLES FOR CONTEXT - NO CONTEXT DATA

ANALYSIS OF VARIANCE TABLES FOR

CONTEXT-NO CONTEXT ANALYSIS: INCLUDING THE BREAKDOWN TRIAL

STAT. GENERAL MANOVA	2(group) X 2(condition) X 3(trial) 1-Group, 2-Condition, 3-Trial Serial Accuracy					
Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1*	9578.32*	18*	1807.734*	5.29852*	.033502*
2	1	663.17	18	529.795	1.25175	.277928
3	2*	11244.01*	36*	202.111*	55.63284*	.000000*
12	1	13.67	18	529.795	.02580	.874178
13	2	210.10	36	202.111	1.03951	.364000
23	2	173.36	36	188.138	.92147	.407114
123	2*	683.34*	36*	188.138*	3.63213*	.036569*

STAT. GENERAL MANOVA	2(group) X 2(condition) X 3(trial) 1-GROUP, 2-CONDITION, 3-TRIAL Transformed Serial Accuracy					
Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1*	133942E3*	18*	210475E2*	6.36380*	.021280*
2	1	9675914.	18	9707336.	.99676	.331328
3	2*	173113E3*	36*	2277824.*	75.99930*	.000000*
12	1	1185118.	18	9707336.	.12208	.730839
13	2	495019.	36	2277824.	.21732	.805719
23	2	3440160.	36	2806480.	1.22579	.305484
123	2*	124357E2*	36*	2806480.*	4.43106*	.019037*

STAT. GENERAL MANOVA	2(group) X 2(condition) X 3(trial) 1-GROUP, 2-CONDITION, 3-TRIAL Absolute Accuracy					
Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1*	3677.454*	18*	459.5202*	8.00281*	.011125*
2	1	70.994	18	162.3122	.43739	.516761
3	2*	3431.298*	36*	90.8833*	37.75498*	.000000*
12	1	65.269	18	162.3122	.40212	.533974
13	2	242.666	36	90.8833	2.67008	.082937
23	2	36.337	36	91.9338	.39525	.676400
123	2	187.262	36	91.9338	2.03692	.145194

STAT. GENERAL MANOVA	2(group) X 2(condition) X 3(trial) 1-GROUP, 2-CONDITION, 3-TRIAL Transformed Absolute Accuracy					
Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1*	798524E2*	18*	104661E2*	7.62965*	.012834*
2	1	772418.	18	3439426.	.22458	.641271
3	2*	821455E2*	36*	1611189.*	50.98438*	.000000*
12	1	664986.	18	3439426.	.19334	.665383
13	2	2132995.	36	1611189.	1.32386	.278749
23	2	544355.	36	1689199.	.32226	.726581
123	2	4618939.	36	1689199.	2.73440	.078426

ANALYSIS OF VARIANCE TABLES FOR

CONTEXT-NO CONTEXT ANALYSIS: PRE-POSTTEST DESIGN

STAT. GENERAL MANOVA	2(group) X 2(condition) X 2(pre-posttrial) 1-GROUP, 2-CONDITION, 3-TRIAL Serial Accuracy					
Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1*	7950.08*	18*	1553.460*	5.11766*	.036292*
2	1	675.70	18	515.762	1.31011	.267368
3	1*	14935.84*	18*	227.378*	65.68742*	.000000*
12	1	.14	18	515.762	.00026	.987217
13	1	163.31	18	227.378	.71822	.407858
23	1	272.69	18	226.795	1.20237	.287303
123	1*	1345.62*	18*	226.795*	5.93319*	.025479*

STAT. GENERAL MANOVA	2(group) X 2(condition) X 2(pre-posttrial) 1-GROUP, 2-CONDITION, 3-TRIAL Transformed Serial Accuracy					
Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1*	991062E2*	18*	152809E2*	6.48562*	.020239*
2	1	110688E2	18	8974933.	1.23330	.281381
3	1*	245012E3*	18*	2906203.*	84.30650*	.000000*
12	1	2420111.	18	8974933.	.26965	.609892
13	1	223076.	18	2906203.	.07676	.784896
23	1	5021373.	18	2789345.	1.80020	.196371
123	1*	235375E2*	18*	2789345.*	8.43835*	.009445*

STAT. GENERAL MANOVA	2(group) X 2(condition) X 2(pre-posttrial) 1-GROUP, 2-CONDITION, 3-TRIAL Absolute Accuracy					
Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1*	2910.078*	18*	334.2149*	8.70721*	.008552*
2	1	28.680	18	125.4693	.22858	.638332
3	1*	5757.921*	18*	123.3089*	46.69510*	.000002*
12	1	9.730	18	125.4693	.07755	.783820
13	1	426.426	18	123.3089	3.45819	.079363
23	1	65.703	18	106.8001	.61520	.443038
123	1	338.253	18	106.8001	3.16716	.092022

STAT. GENERAL MANOVA	2(group) X 2(condition) X 2(pre-posttrial) 1-GROUP, 2-CONDITION, 3-TRIAL Transformed Absolute Accuracy					
Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1*	596370E2*	18*	7012095.*	8.50488*	.009215*
2	1	240740.	18	2369183.	.10161	.753572
3	1*	136931E3*	18*	2215777.*	61.79799*	.000000*
12	1	5776.	18	2369183.	.00244	.961163
13	1	3720864.	18	2215777.	1.67926	.211394
23	1	934198.	18	1759171.	.53104	.475543
123	1*	8194196.*	18*	1759171.*	4.65799*	.044663*

ANALYSIS OF VARIANCE TABLES FOR

CONTEXT-NO CONTEXT ANALYSIS: NO CONTEXT CONDITION

WITH CONTEXT ADDED ON TRIAL 3

STAT. GENERAL MANOVA	2(group) X 3(trial) 1-GROUP, 2-TRIAL Serial Accuracy No Context with Context Added On					
Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1*	6882.246*	18*	1230.906*	5.59120*	.029490*
2	2*	3717.011*	36*	132.832*	27.98281*	.000000*
12	2	179.583	36	132.832	1.35196	.271554

STAT. GENERAL MANOVA	2(group) X 3(trial) 1-GROUP, 2-TRIAL Transformed Serial Accuracy No Context with Context Added On					
Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1*	120846E3*	18*	169627E2*	7.12426*	.015643*
2	2*	582063E2*	36*	1798278.*	32.36778*	.000000*
12	2	5843611.	36	1798278.	3.24956	.050420

STAT. GENERAL MANOVA	2(group) X 3(trial) 1-GROUP, 2-TRIAL Absolute Accuracy No Context with Context Added On					
Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1*	1210.504*	18*	169.6202*	7.13655*	.015567*
2	2*	1887.225*	36*	77.6312*	24.31014*	.000000*
12	2	86.360	36	77.6312	1.11244	.339793

STAT. GENERAL MANOVA	2(group) X 3(trial) 1-GROUP, 2-TRIAL Transformed Absolute Accuracy No Context with Context Added On					
Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1*	294223E2*	18*	4067684.*	7.23317*	.014983*
2	2*	479849E2*	36*	1561594.*	30.72817*	.000000*
12	2	1652711.	36	1561594.	1.05835	.357578

APPENDIX D

QUESTIONNAIRE: EXPERTISE IN THE MARTIAL ARTS

PART ONE:

Name: ______________________________

Age: _________

1) How old were you when you began participating in karate? _______

2) How old were you when you became involved more full-time or on a year-round basis, if at all? _______

3) What is your present belt classification? _______

4) Please outline your progression through the different classification levels:

Belt	Year	Age
white	_________	_________
gold	_________	_________
orange	_________	_________
green	_________	_________
purple	_________	_________
blue	_________	_________
red	_________	_________
camouflage	_________	_________
brown	_________	_________
black stripe	_________	_________
black (1st degree)	_________	_________
black (2nd degree)	_________	_________
black (3rd degree)	_________	_________
black (4th degree)	_________	_________
black (5th degree)	_________	_________

5) Please outline your attendance at martial arts seminars/clinics. If you need more space, please use the back of this page.

Seminar/Clinic	Year

6) Have you ever given any seminars/clinics? If so, please list. If you need more space, please use the back of this page.

Seminar/Clinic	Year

7) Please outline your participation in martial arts competitions/tournaments. If you require more space, please use the back of this page.

COMPETITION/TOURNAMENT	YEAR	PLACING

8) In the table provided, please record the duration of your off-season (in weeks) at various times throughout your career. You will probably find that you will not need all of the columns unless you have been involved in karate for 17 years or more, so please stop when you reach a column that corresponds to the number of years that you have been involved in karate.

YEAR	START	3rd	5th	7th	9th	11th	13th	15th	17th	LAST YEAR
AGE										
OFF-SEASON (WEEKS)										

9) How many instructors have you had over the course of your career ? ________

10) How long have you been with your current instructor(s) ? ________

11) At what point in your karate career do you now consider yourself?
Circle one:

PRE-PEAK PEAK PAST PEAK

12) Do you have any specific goals related to karate that you would like to achieve this year? If so, please describe.

____
____
____
____
____
____

PART TWO: ACTIVITY QUESTIONNAIRE

We are interested in finding out what a 'typical week' was like for you at different times through your karate career. A number of activities have been divided into four groups. These groups are as follows;

1) practice with others
2) practice alone
3) activities related to karate
4) activities unrelated to karate

As you read through the activities, please choose and record one of the times provided which represents, on average, the amount of time you would have spent engaging in each activity. When you think of a 'typical week', try to think of one occurring mid-way through the season.

The first column corresponds to the age that you first began karate. Please write underneath the column headings the ages that you were at the specific times. You will probably find that you will not need all of the columns unless you have been involved in karate for 17 years or more, therefore, please stop when you reach the column corresponding to the age you are now. After you have filled in the estimates of time spent in each activity for the first column, repeat this procedure for column two; that is for the age you were two years after first beginning karate. Continue with this procedure until you reach the column corresponding to the age you are now.

EXAMPLE:

Choose one of the following ranges of time for each activity;

a) 0 hours/week
b) up to and including 2h/wk
c) >2h/wk or ≤ 4h/wk
d) >4h/wk or ≤ 6h/wk
e) >6h/wk or ≤ 8h/wk
f) >8h/wk or ≤10h/wk
g) >10h/wk or ≤12h/wk
h) >12h/wk or ≤ 14h/wk
i) > 14h/wk

*** **IF YOU ARE ABLE TO RECALL EXACT AMOUNTS OF TIME, PLEASE DO SO.**

YEAR	START	3rd	5th	7th	9th	11th	13th	15th	17th	LAST
AGE	13	15	17							18
ACTIVITY	HOURS PER WEEK (choose one of a - i)									
swimming	a	c	c							1HR

For this example the individual began participating in karate when he/she was 13 years old. During the first year, this individual did not spend any time swimming during a typical week. During the third and fifth year of his/her karate career (15 and 17 years old, respectively), greater than 2, but less than 4 hours was spent swimming during a typical week. Last year, when this individual was 18 years old (6th year of participation in karate), one hour per week was spent swimming during a typical week.

On completion of the first section you will be required to rate the activities on various dimensions before going on to the next group of activities. A rating scale from 0(low) - 10(high) will be used to rate the activities on the following four dimensions;

1) **Relevance** of the activity to improving karate performance.
2) How much **effort** (physical work) is required to perform the activity.
3) How **enjoyable** the actual activity itself is (as opposed to the result of the activity).
4) How much **concentration** (mental work) is required to perform the activity.

EXAMPLE:

ACTIVITY	RATING FROM 0 - 10			
	Relevance to improving karate performance 0=irrelevant 10=extremely relevant	**Effort** (physical work) required to perform the activity 0=not at all effortful 10=extremely effortful	How **enjoyable** the activity is 0=not at all enjoyable 10=extremely enjoyable	**Concentration** (mental work) required to perform the activity 0=no concentration 10=extreme concentration
swimming	5	9	2	9

For this example the individual has rated swimming as an activity that is moderately relevant to improving karate performance. For this individual, swimming is an activity that requires a great amount of effort and concentration, and is one that he/she does not enjoy very much.

A) PRACTICE WITH OTHERS

How many hours would you have spent in a typical week practicing with others? This practice would include the following activities:

- sparring
- jogging
- weight training
- flexibility training
- swimming
- cycling
- group class with an instructor
- basics/kata training
- impact (shield) training
- other activities (please describe): ___________

Choose one of the following ranges of time for each activity;

a) 0 hours/week
b) up to and including 2h/wk
c) >2h/wk or ≤ 4h/wk
d) >4h/wk or ≤ 6h/wk
e) >6h/wk or ≤ 8h/wk
f) >8h/wk or ≤10h/wk
g) >10h/wk or ≤12h/wk
h) >12h/wk or ≤ 14h/wk
i) > 14h/wk

***** IF YOU ARE ABLE TO RECALL EXACT AMOUNTS OF TIME, PLEASE DO SO.**

YEAR	START	3rd	5th	7th	9th	11th	13th	15th	17th	LAST
AGE										
ACTIVITY	HOURS PER WEEK (choose one of a - i)									
sparring										
jogging										
weight training										
flexibility training										
swimming										
cycling										
group classes with instructor										
basics /kata training										
impact (shield) training										
other										

Now rate each of these activities on the four dimensions described earlier.

ACTIVITY (performed with partner(s))	**RATING FROM 0 - 10**			
	Relevance to karate performance 0=irrelevant 10=extremely relevant	**Effort** (physical work) required to perform the activity 0=not at all effortful 10=extremely effortful	**How enjoyable** the activity is 0=not at all enjoyable 10=extremely enjoyable	**Concentration** (mental work) required to perform the activity 0=no concentration 10=extreme concentration
sparring				
weight training				
jogging				
flexibility training				
swimming				
cycling				
group classes with instructor				
basics/kata training				
impact (shield) training				
other				

B) PRACTICE ALONE

How many hours in a typical week would you have spent practicing karate alone? This practice would include the following activities;

- weight training
- flexibility training
- jogging
- working alone with your instructor
- watching karate videos
- swimming
- cycling
- punching bag training
- basics/kata training
- other activities (please describe): ____________________

Choose one of the following ranges of time for each activity;

a) 0 hours/week
b) up to and including 2h/wk
c) >2h/wk or ≤ 4h/wk
d) >4h/wk or ≤ 6h/wk
e) >6h/wk or ≤ 8h/wk
f) >8h/wk or ≤10h/wk
g) >10h/wk or ≤12h/wk
h) >12h/wk or ≤ 14h/wk
i) > 14h/wk

***** IF YOU ARE ABLE TO RECALL <u>EXACT</u> AMOUNTS OF TIME, PLEASE DO SO.**

YEAR	START	3rd	5th	7th	9th	11th	13th	15th	17th	LAST
AGE										
ACTIVITY	HOURS PER WEEK (choose one of a - i)									
weight training										
flexibility training										
jogging										
working alone with instructor										
watching karate videos										
swimming										
cycling										
basics/kata training										
punching bag training										
other										

Now rate each of these activities on the four dimensions described earlier.

ACTIVITY (performed alone)	RATING FROM 0 - 10			
	Relevance to karate performance 0=irrelevant 10=extremely relevant	**Effort** (physical work) required to perform the activity 0=not at all effortful 10=extremely effortful	**How enjoyable** the activity is 0=not at all enjoyable 10=extremely enjoyable	**Concentration** (mental work) required to perform the activity 0=no concentration 10=extreme concentration
weight training				
flexibility training				
jogging				
working alone with instructor				
watching karate videos				
swimming				
cycling				
basics/kata training				
punching bag training				
other				

C) ACTIVITIES RELATED TO KARATE

How many hours during a typical week would you have spent in karate-related activities? These activities may include the following;

diet planning/nutrition
keeping a training journal
watching karate (live, TV, video)
reading karate theory (may include diets, techniques, psychological training in books or magazines, etc.)
instructing
professional conversation (with other karate students, instructors, etc.)
mental rehearsal (may be time spent thinking about what happened during class or while testing for a belt)
attendance at seminars/clinics (for example, the psychology of martial arts)
other activities (please describe): ________________________________

Choose one of the following ranges of time for each activity;

a) 0 hours/week
b) up to and including 2h/wk
c) >2h/wk or ≤ 4h/wk
d) >4h/wk or ≤ 6h/wk
e) >6h/wk or ≤ 8h/wk
f) >8h/wk or ≤10h/wk
g) >10h/wk or ≤12h/wk
h) >12h/wk or ≤ 14h/wk
i) > 14h/wk

***** IF YOU ARE ABLE TO RECALL EXACT AMOUNTS OF TIME, PLEASE DO SO.**

YEAR	START	3rd	5th	7th	9th	11th	13th	15th	17th	LAST
AGE										
ACTIVITY	HOURS PER WEEK (choose one of a - i)									
diet planning/nutrition										
training journal										
watching karate										
reading karate theory										
instructing										
professional conversation										
mental rehearsal										
seminars/clinics										
other										

Now rate each of these activities on the four dimensions described earlier.

ACTIVITY (related to karate)	RATING FROM 0 - 10			
	Relevance to karate performance 0=irrelevant 10=extremely relevant	**Effort** (physical work) required to perform the activity 0=not at all 10=extremely effortful	**How enjoyable** the activity is 0=not at all enjoyable 10=extremely enjoyable	**Concentration** (mental work) required to perform the activity 0= no concentration 10=extreme concentration
diet planning/nutrition				
training journal				
watching karate				
reading karate theory				
instructing				
professional conversation				
mental rehearsal				
seminars/clinics				
other				

D) EVERYDAY ACTIVITIES (NOT RELATED TO KARATE)

How many hours in a typical week would you have spent engaging in activities that are not related to karate? These activities may include the following;

sleeping
academic study/school
active leisure (includes participating in other sports)
part/full-time work
non-active leisure (includes watching TV, reading (unrelated to karate), playing games (e.g. cards, darts), socialising, playing a musical instrument, listening to music, etc.
other (please describe): ______________________

Choose one of the following ranges of time for each activity;

a) 0 hours/week
b) up to and including 2h/wk
c) >2h/wk or ≤ 4h/wk
d) >4h/wk or ≤ 6h/wk
e) >6h/wk or ≤ 8h/wk
f) >8h/wk or ≤10h/wk
g) >10h/wk or ≤12h/wk
h) >12h/wk or ≤ 14h/wk
i) > 14h/wk

*** **IF YOU ARE ABLE TO RECALL <u>EXACT</u> AMOUNTS OF TIME, PLEASE DO SO.**

YEAR	START	3rd	5th	7th	9th	11th	13th	15th	17th	LAST
AGE										
ACTIVITY	HOURS PER WEEK (choose one of a - i)									
sleeping										
academic study/school										
active leisure										
part/full-time work										
non-active leisure										
other										

Now rate each of these activities on the four dimensions described earlier.

ACTIVITY (not related to karate)	RATING FROM 1 - 10			
	Relevance to karate performance 0=irrelevant 10=extremely relevant	**Effort** (physical work) required to perform the activity 0=not at all effortful 10=extremely effortful	How **enjoyable** the activity is 0=not at all enjoyable 10=extremely enjoyable	**Concentration** (mental work) required to perform the activity 0=no concentration 10=extreme concentration
sleeping				
academic study/school				
active leisure				
part/full-time work				
non-active leisure				
other				