The Effects of Mental Imagery, Video Modeling, and Physical Practice On the Rate of Acquisition of a New Figure Skating Skill

by

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For Carol, my mom,

Who taught resilience, strength, and the effectiveness of a messy table.

Abstract

This thesis examined the effects of mental imagery (MI) and video modeling (VM) on the rate of acquisition of a figure skating skill by developmental level figure skaters (7-10-years-old). Two groups (*N*=16) were purposively assigned to receive either MI+VM with on-ice practice (PP) or PP only. Based on Craik and Lockhart's (1972) theoretical memory framework (Levels of Processing; LOP), MI and VM were examined as methods to increase the depth of cognitive processing in figure skaters and create sustained memory retention, reducing the number of physical trials required to acquire a complex motor skill, the Inside Axel jump. The results indicated a slightly positive effect for MI+VM+PP, which suggests that MI and VM create deeper LOP. This study suggests that MI and VM are useful additions to traditional methods of coaching. Also discussed are motor skills and their acquisition, observational learning, model selection, and developmental aspects of children and memory.

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Introduction

When you walk into any skating rink in the country and see young figure skaters practicing complex spins and jumps, it is not long before you see one, if not all of them, falling repeatedly as they struggle to learn these skills. It is no surprise that injuries occur and are, in fact, on the rise (Lipetz & Kruse, 2000). While some researchers and physicians point to increasing core muscular strength or improving equipment to decrease the chance of injury (Bloch, 1999; Lipetz & Kruse), a sport psychology and motor learning perspective may offer an alternative: Can mental imagery and video modeling decrease the number of physical trials required to learn a motor skill? Specifically, will a combination of mental imagery and video modeling decrease the number of physical trials required by developmental figure skaters to learn a new figure skating skill (a jump) as compared to the number required through physical practice alone?

The central purpose of this study was to investigate the effects of mental imagery (MI) and video modeling (VM) combined with physical practice (PP), as compared to physical practice (PP) alone, on the number of repetitions necessary to consistently (4 out of 5 times) complete a new figure skating skill.

Recent advances in equipment, technique and rules, and increases in media coverage have created innumerable changes to and progress in the sport of figure skating. One of these changes has been the elimination of "figures" in both competition and practice settings. The removal of figures has led to an increase in the time skaters spend practicing the other disciplines of figure skating, such as freeskate (e.g., jumps, spins, freeskate long and short programs), and to a rapid acceleration in the technical difficulty of jumps, spins, and choreography. Training time for figure skating is extensive at both the competitive and developmental levels. Competitive figure skaters train year-round, with on- and off-ice training averaging up to 30 hours per week (Lipetz & Kruse, 2000). Developmental level skaters can skate year-round as well, training anywhere between 9-25 hours per week. As practice time has increased, the age of the skaters competing at high performance levels has decreased. Figure skaters often specialize early, some beginning rigorous training as young as 5 years of age (Lipetz & Kruse; Starkes, Deakin, Allard, Hodges, & Hayes, 1996), and are completing jumps with two revolutions by the age of 8 (Lipetz & Kruse). There is often a sense of urgency to have young skaters, especially females, consistently landing all double jumps and some triple jumps before they reach puberty; it is believed to be easier to maintain the capacity to land difficult double and triple jumps through puberty than to learn them after (Smith, 2000). These increased demands include an inherent risk of injury (Bloch, 1999; Lipetz & Kruse), particularly to skaters' lower extremities, including fractures, growth plate injuries, as well as core musculature injuries (Lipetz & Kruse; Smith).

Another significant cost in figure skating is financial. Coaching, equipment, and ice costs are high, and at the competitive level, costs can soar into the tens of thousands of dollars yearly (Smith, 2000). To decrease both the physiological and financial costs of this sport, alternative methods of acquiring these technically challenging and physiologically demanding skills, through learning in faster and safer ways, need to be explored and established.

Two methods frequently used to facilitate learning and performance are mental imagery and observational learning via video modeling. For example, it has been well documented throughout both the sport psychology and motor learning literature that imagery can facilitate the learning and performance of motor skills (see Feltz & Landers, 1983; Grouios, 1992 for reviews). Relatively few studies, however, have investigated the effects of imagery on complex motor skill acquisition, and in particular, on the acquisition of sports skills in a field setting (i.e., whether the implementation of imagery training has an effect on the rate of learning, and if so, how or why this change occurs). Video modeling is also used in sport as a teaching tool, and has been documented as a powerful intervention in its own right (Dowrick & Jesdale, 1991) and as a viable training method (Starkes & Lindley, 1994). Using video in learning situations is an inexpensive, yet effective, supplemental training method with advantages including less on-site practice, less need for a coach to be present, increased possibility for self-paced learning, and minimal equipment costs (Starkes & Lindley).

There is a need to further explore mental imagery and video modeling as alternate training methods with young athletes, especially in a high cost sport such as figure skating. Although the popularity of youth sport research has been growing in the last two decades (Gould, 1996), studies of both imagery and video modeling are limited in the youth sport literature (Atienza, Balaguer, & Garcia-Merita, 1998). This study sought to explore imagery and video modeling in youth sport, with the major focus of discovering the effects of, as well as providing evidence for, the practice condition (mental imagery, video modeling, and physical practice, versus physical practice only) that required the least number of physical trials for learning a new figure skating jump. Specifically, this study aimed to provide evidence for mental imagery and video modeling as creating deeper levels of processing in developmental level figure skaters for a specific figure skating jump, thereby increasing retention for the jump, and resulting in fewer physical trials to acquire the jump.

Review of Literature

Mental Imagery

Richardson (1969) defined imagery as "those quasi-sensory and quasi-perceptual experiences of which we are self-consciously aware and which exist for us in the absence of those stimulus conditions that are known to produce their genuine sensory or perceptual counterparts" (pp. 2-3). Since Richardson's early definition, White and Hardy (1998), further defined imagery as "an experience that mimics real experience. We can be aware of 'seeing' an image, feeling movements as an image, or experiencing an image of smell, tastes, or sounds without actually experiencing the real thing" (p. 389). Imagery has been seen as a major component of a larger process: mental practice (Hall, 1985), which has been described as "improvement in performance that results from an individual's either thinking about a skill or watching someone else perform it" (Marteniuk, 1976, p. 224, as cited in Hall, 2001). Mental practice is believed to be larger in scope than imagery and includes other processes, such as observational learning (Hall, 1985). As Grouios (1992) pointed out in his review of mental practice in the literature, many terms have been used interchangeably to refer to imagery or mental practice (e.g., mental rehearsal, image training, imagery practice, mental review, and symbolic practice). To clarify this term, Hall (2001) states that, most studies using mental practice [or otherwise termed] have been concerned with the effect of imagery on motor performance, and Hall proposes that any study that focuses on imagery effects should be considered imagery research. This paper focuses on the effects of imagery, or mental practice, on the rate of acquisition of a complex motor skill, and as Hall (2001) suggested, the term "imagery" will be used.

Imagery and skill acquisition. Imagery research has repeatedly shown that imagery can enhance and facilitate skill acquisition and performance (Feltz et al., 1983; Goss, Hall, Buckolz, & Fishburne, 1986; Hall, Buckolz, & Fishburne, 1992; Martin, Moritz, & Hall, 1999). Researchers have made recommendations as to what is important to consider when conducting imagery research. These include when, where, and why imagery has been used effectively by athletes, the variables that influence the use of imagery (i.e., type of activity or nature of the task; performer's skill level; performer's imagery ability; imagery instructions) (Hall, 2001; Hall, Schmidt, Durand, & Buckolz, 1994), what combinations of physical and mental practice have been shown to be effective, and the type of imagery to be used (i.e., internal, external, kinesthetic) (Janssen & Sheikh, 1994).

In a study of where, when, why and what athletes were imaging, with 14 varsity athletes from various sports Munroe, Giacobbi, Hall and Weinberg (2000) discovered that while athletes use imagery in both practice and competition, imagery is often used more for performance enhancement or execution than for skill learning. However, it has been argued that imagery may be most effective in the initial stages of motor skill learning based on the premises that the initial stage of learning a skill is primarily cognitive in nature and that imagery facilitates the rehearsal of these cognitive components (Wrisberg & Ragsdale, 1979). A study by Bohan, Pharmer, and Stokes (1999) examined the question of when imagery would be most effective in learning a novel motor task. Their results showed that the effects of imagery were most evident in the early stages of learning as compared to intermediate or late stages, due to the task becoming automated in the later stages.

Another consideration is the skill level of the athlete and whether a difference exists between novice and skilled athletes in regards to success in imaging. Generally, imagery does have different levels of effectiveness for novice and skilled athletes, but usually this is attributed to individual imaging ability rather than level of athletic performance. Trained athletes, including figure skaters, have been found to possess high imaging ability (Mumford & Hall, 1985) and should be able to use imagery effectively (Munroe et al., 2000). While it seems reasonable that individuals with poor imaging ability will most likely not experience effective improvements in motor tasks by using imagery (Munroe et al.), it is important to acknowledge that imagery ability can be trained. A study of the effects of imagery training on figure skating performance revealed that imagery training does improve imagery ability (Rodgers, Hall, & Buckolz, 1991). This finding is important to skill acquisition as high movement imagery ability facilitates the acquisition of motor patterns (Goss et al., 1986).

The imagery perspective of the individual is also important. There are two imagery perspectives: external and internal. External imagery requires individuals to imagine seeing themselves perform as though on video or in a movie. Internal imagery occurs when individuals imagine themselves performing and seeing what they would see if they were physically executing the skill. When imaging or seeing oneself perform is taken a step further and individuals try to "feel" what physical execution of the skill would be like, along with seeing the image of themselves, it is referred to as kinesthetic imagery. Kinesthetic imagery can be used with either external or internal imagery (Hall, 2001). While there is conflicting evidence concerning which perspective has superior effects on the acquisition of skills (White & Hardy, 1995), researchers suggest that a combination of perspectives may be advantageous (Rodgers et al., 1991). Imagery instructions might also be given careful consideration. The instructions should contain sufficient detail to ensure that all the participants are imaging the same thing regardless of their imagery perspective or ability (Hall, 1985).

Researchers assert that prior experience in the task is necessary for imagery to be effective (Corbin, 1972; Hall, Buckolz, & Fishburne, 1989), but others argue that as long as the movements that constitute the new skill or new sequence of movements are familiar to the learner, mental practice may be effective without prior experience of the task (Bohan et al., 1999; Minas, 1980). Jones (1965, as cited in Minas, 1980) found that motor learning through mental practice could occur without prior experience in the task if guided instructions were provided.

The nature of the task is also a consideration, because it has been shown that tasks that are highly cognitive in nature will benefit from imagery more than those that are purely motor or essentially only require strength (Feltz & Landers, 1983). Skills can be seen on a continuum from those that are primarily cognitive (e.g., maze learning, complex choreography in skating routines) to those that have few cognitive elements (e.g., dart throwing, basic forward or backward skating) (Feltz & Landers). However, whereas it is likely too difficult to measure the amount of cognitive elements in a task, it seems reasonable to assume that all tasks contain at least some cognitive components and therefore could be improved via imagery (Ryan & Simons, 1983).

Combining imagery and physical practice. It has been frequently documented that combining imagery with physical practice has a positive effect on motor task performance (Feltz & Landers, 1983; Grouios, 1992). Research demonstrates that imagery, along with physical practice, has a greater effect on performance than physical practice alone, and imagery alone is better than no physical practice, but imagery alone is not as effective as physical practice alone (see Grouios for a review). From these findings, it appears that imagery should be used in conjunction with physical practice and not as a replacement for it.

Measuring imagery ability. Athletes' ability to image is commonly measured via the Mental Imagery Questionnaire (MIQ; Hall & Pongrac, 1983). (See Appendix A). The MIQ is used to assess individual differences in movement imagery, measuring both visual and kinesthetic movement imagery, and is scored in such a way that lower scores indicate higher imaging ability. Several studies have found the MIQ to be a sufficient and acceptably reliable measure of imagery ability (Atienza, Balaguer, & Garcia-Merita, 1994; Goss et al., 1986; Hall et al., 1989; Mumford & Hall, 1985). The MIQ can be used to compare an individual's imaging ability pre- and post imagery interventions (e.g., Rodgers et al., 1991), as well as a control to determine whether differences in imagery ability among experimental groups exist (e.g., Hall, Bernoties, & Schmidt, 1995).

Motor Skills

Classifying motor skills. Motor skills may be placed on a continuum of movements ranging from fine to gross, with classification based on several factors (e.g., the size of the muscle involved; the amount of force applied; the magnitude of space in which the movement is carried out). Movements that involve the total body or multi-limbs are considered as gross motor skills and movements that require control of the small muscles of the body are classified as fine motor skills (Magill, 2001; Sage, 1971).

Further, motor skills can be considered as discrete, serial, or continuous. Discrete skills involve a single exertion and have a clearly defined beginning and end point (e.g., flipping a light switch, throwing a dart, performing a figure skating jump or spin). Serial skills require a series of movements to complete a task, and thus could be defined as a sequence of discrete skills (e.g., performing a freeskate program or dance routine). Continuous skills require repetition of movement patterns and have relatively arbitrary beginning and end points, such as running, swimming, or skating distances (Magill, 2001; Sage, 1971). Skills are also classified environmentally, as open or closed. Open skills are largely influenced by outside factors and changing environments, while closed skills take place in fixed, unchanging environmental conditions. Returning tennis serves during a match or receiving a teammate's pass in a hockey game would be considered open skills because they are largely a reaction to outside circumstances. On the other hand, executing a jump or spin in figure skating or hitting a ball off a tee would be considered closed skills, as the performer determines when the action or skill will begin, and only static objects would be involved.

Skill, skill acquisition or learning, and performance. The differences between skill, skill acquisition, and performance must be made clear. Skill has been described in varying ways: (a) as "a behavioral solution to a particular class of problems" (Annett, 1991, p.14); (b) as related "to an underlying capability or potential to perform at a certain level" (Lee, Chamberlin, & Hodges, 2001, p.115); and (c) as "a wide variety of complex, learned behaviors that depend heavily on motor processes for goal attainment" (Schendel & Hagman, 1991, p.54). The commonality in these definitions is that behavior is goal-directed and acquired through practice. Skill is not innate or instinctive (Annett), but a behavior that is learned. Skill is acquired as a result of repetitive practice and through various methods of instruction that involve cognitive processes (Annett).

Performance vs. learning. Performance is "the motor behavior exhibited on a task that can be measured" (Lee et al., 2001, p.115) and is how a task is executed at any given time (Thomas Thomas, Gallagher, & Thomas, 2001). Learning, however, is "a change in the capability of a person to perform a skill that must be inferred from a relatively permanent improvement in performance as a result of practice or experience" (Magill, 2001, p. 169). Performance, by definition, is variable and any given performance can be affected by factors external to the ability of a performer. For example, environmental conditions such as poor ice quality or individual variables such as fatigue can affect performance but may not necessarily affect the ability of the performer to execute the skill. Simply stated, the learning that has been acquired does not decrease due to these external factors.

Stages of learning. Learning is considered to be a continuous process that involves time and practice and is thought to occur in stages or phases (Magill, 2001). Several researchers have endeavored to identify the stages of learning, but Fitts and Posner's (1967) approach is traditionally accepted as the classic stages of learning model (Magill). Fitts and Posner identified three phases of skill learning: the cognitive, associative, and autonomous stages and regarded progression through these stages as continuous. While it is difficult to identify strict stages in skill acquisition, Fitts and Posner's description illustrates how task performance appears to change over a period of practice (Colley, 1989).

The early or cognitive stage occurs when the learner organizes the new movement task by reference to similar patterns within his/her own repertoire of previously learned skills (Fitts & Posner, 1967). Unnecessarily gross and effortful movements, as well as variable performance, mark this stage of learning (Magill, 2001) due to the large amount of information (e.g., kinetic, instructive, and environmental) the learner is subjected to (Colley, 1989). During this stage, verbal instructions and demonstrations are most effective (Fitts & Posner). However, recent research (Bouchard & Singer, 1998), has pointed out that too much information or instruction may be detrimental to performance by posing too much cognitive demand on the learner. The recommendation is to keep instructions at this stage simple, but not at the expense of achieving the task goal (Lee et al., 2001).

The intermediate, or associative, phase is a period when the cognitive activity characterizing the cognitive stage changes. The basic mechanics of the skill have been learned and now refinement of the skill and new patterns of movement begin to emerge (Fitts & Posner, 1967). During this stage, self-regulation begins, gross errors are gradually eliminated, and variability of performance begins to decrease (Fitts & Posner).

The final, or autonomous, stage occurs when the skill has become almost automatic or habitual. The movement pattern is less directed by cognitive control and less subject to interference from extraneous environmental factors or distractions (Fitts & Posner, 1967). Movement patterns are now executed without conscious attention to the individual subcomponents of the movement, and while speed and efficiency can continue to improve, they will likely do so at a continually decreasing rate (Fitts & Posner, 1967).

Practice and learning. Another major factor in learning is practice (Lee et al., 2001). In research situations the arrangement or spacing of the practice sessions must be considered. A recent study found that the most effective distribution of practice sessions is across an interval of days rather than within days (Shea, Lai, Black, & Park, 2000).

Assessment of learning. Learning cannot be observed directly; learning is inferred through the observation of performance, with the assessment of learning being drawn from these performances (Magill, 2001). In motor skill learning, changes in performance were historically tracked through changes in independent variables (e.g., time to complete a task, magnitude of error, and amount of work accomplished per attempt or per unit of time) plotted on a learning curve (Annett, 1991).

When movement outcome is the variable of interest error measurements can be calculated. For example, variable error (VE) is determined in situations where consistency of performance is important and constant error (CE) in situations where accuracy is important (Schmidt & Lee, 1999). An example is a goal type situation such as archery or dart throwing. The placement of the arrows or darts can be measured for distance, and the amounts of error for consistency or accuracy calculated. When these types of quantitative changes (e.g., measures of distance, accuracy) are not the variable of interest, or calculating error is not suitable, other types of assessments may provide an alternative for recording permanent changes in performance or learning.

These alternative assessments constitute recording observed changes in technique and movement patterns, as well as decreases in effort, and increases in effective working methods (Annett, 1991). These changes can be recorded through the use of practice observations and retention tests (RT) (Magill, 2001; Sage, 1971). The use of practice observation requires keeping a performance record for the duration of the learning period and determining whether or not performance improvement or consistency changes are occurring (Magill). For example, the performance record would indicate the number of repetitions required to successfully complete a skill.

Retention tests compare two or more performance scores of the same task. Usually a test will be given at the beginning of the learning, one at the end of the learning period, and a third test, the RT, completed after a period of time where the skill is not practiced. The time of the no-practice interval can be of any length (Magill, 2001). The RT is done in this manner to examine the relative permanence of the changes in skill that were brought about through practice (Lee et al., 2001). The use of RTs allows for common bases to be examined in groups that have received different practice conditions (Lee et al.).

Motor skill acquisition and imagery research. Most of the research involving skill acquisition and imagery involves discrete motor skills, such as dart throwing or golf putting (Blair, Hall, & Leyshon, 1993) or pantograph tracing (Goss et al, 1986), as the tasks are simple and can be learned in a short time. Few studies have used motor skills that include serial or continuous tasks (Blair et al.; Minas, 1978; Mumford & Hall, 1985). Some studies have reported increases in rates of acquisition (Goss et al.; Hall et al., 1989; Lovell & Collins, 1997), but none have specifically investigated whether or not the actual time or number of trials to learn and retain the skill had been affected due to imagery.

Observational Learning/Modeling

Bandura's theory of observational learning was originally formulated in the context of social learning theory (McCullagh, 1986) and is based on the notion that learning principally occurs through imitation and observation of others (Bandura, 1986). Bandura sees learning as an information-processing activity in which information about behavior is transformed into symbolic representations that guide action. Providing a model of thought and action is one of the most effective ways to convey information (Bandura). In skill acquisition, modeling is represented as rule learning rather than simple imitation or mimicry (Bandura). Simply stated, modeling, through the use of demonstrations, is a means of conveying information about how to perform skills. According to Bandura, observational learning is governed by four sub processes: (a) attentional processes that regulate exploration and perception of the modeled activities; (b) retention processes where transitory experiences are converted for memory representation into symbolic conceptions that serve as internal models for response production and standards for response correction; (c) production processes that govern the organization of constituent subskills into new response patterns; and (d) motivation processes that determine whether or not observationally acquired competencies will be put to use.

Learning through the use of observations, or modeling, is helpful to both the beginner and the experienced performer. The use of demonstrations in the early stage of skill learning should enable the learner to perceive the important relationships between the body parts and, more specifically, the relative motions of the skill (Scully & Newell, 1985). Franks and Maile (1991) further describe modeling as a vital component in the processes of coaching and teaching motor skills.

The optimal time to view the demonstration in relation to overt practice must also be considered. Unfortunately, research results about this optimal time are equivocal. In one study, the age of the observer was taken into consideration; 7 and 9 year old children viewed models prior to acquisition and mid-acquisition (Thomas, Pierce, & Rigsdale, 1977, as cited in Weeks & Anderson, 2000). The younger children did not benefit from the mid-acquisition models. Another study, examining observational learning of a volleyball serve involving undergraduate students, found that the interaction between observational learning and overt practice was most effective for skill acquisition when several pre-practice observational experiences were combined with inter-practice observational experiences, as long as the inter-practice modeling was halted relatively early in the practice sequence (Weeks & Anderson). Specifically, the participants that scored best on a RT viewed a total of ten serves; five pre-practice and then five more after practice had started (one every three serves for total of thirty serves). In light of these findings, Weeks and Anderson suggest that uninterrupted practice should be scheduled immediately following modeling to allow for trial-and-error learning and that the demonstrations should finish by the mid-point of the practice.

Selection of Models

Modeling situations can vary in how the demonstrations are performed and by whom (e.g., by an instructor, a peer, a learning model, a skilled or expert performer, a live performance, a videotaped performance, etc.,), as well as the mood of the situation (e.g., anxiety provoking situations versus normal learning situations). In selecting appropriate models it is important to consider not only the type of learning situation, but the characteristics of both the observer and the model as well. Researchers have attempted to illuminate the most effective type of model and the factors or characteristics that should be considered during model selection in various settings with various populations. The findings have been somewhat equivocal, however.

Types of models. Many types of models have been examined including skilled-mastery or correct models (high level performers, or teachers), coping or learning models (often are peers of similar age and performance level of the observer), multiple models (when one or more models are viewed), and high status models. Studies, examining whether a learning model or a skilled model is more effective, have found support for both cases. For example, Martens, Burwitz, & Zuckerman (1976) suggested that for highly cognitively demanding skills a more skilled model demonstrating the correct movement pattern might be most appropriate. On the other hand, Schunk, Hanson and Cox (1987) suggested that for 'normal' learners (versus learners who find the task to be learned anxiety provoking, or have difficulty learning new tasks), observing a mastery model may be more appropriate, as this would promote self-efficacy better than a coping or learning model. In a field study involving video taped models and young athletes as the observers, high status models (i.e., professional table tennis players) were viewed, and significant increases in performance were documented (Li-Wei, Qi-Wei, Orlick, & Zitzelsberger, 1992).

Support for the use of learning models has also been offered (Adams, 1986; Hebert & Landin, 1994; McCullagh & Caird, 1990). In a study involving feedback and learning models, where knowledge of results (KR) about the observers own movements was not received, it was shown that a learning model was more effective, because the learners could glean information regarding KR from the model's mistakes and corrections (Hebert & Landin, 1994). However, the researchers noted that it was not clear what the outcome would be if the feedback were not provided.

The use of multiple or different types of models has been shown to be effective as well. Using multiple models involves having more than one model, who vary in personal or skill related characteristics (Weiss, Ebbeck, & Wiese-Bjornstal, 1993). The intention is to increase the likelihood that the observer will identify with at least one of the models, as well as to facilitate the generalizability of the models' behavior (Weiss et al.). A study involving observational learning via video (Atienza et al., 1998), employed demonstrations by a coach, similar coping models, multiple models, and high status models, and the results indicated that increases in performance and technique were significant in all cases.

Observer/model similarity. Intuitively, it would seem that a model close to the observer's age, as well as the same gender, would promote the learner's self-efficacy regarding his or her ability to complete the task more than a dissimilar model would. The underlying mechanism here is related to increased motivation and attention stemming from a possible bond that similarity may create between the learner and the model (Weiss et al., 1993). However, Schunk et al. (1987) discovered that as long as the learner perceived that the outcome of the task was attainable and appropriate, the gender of the model was not an influential factor. Also, the distinction of the age range that is considered to be similar enough to the learner has not been clearly delineated and peer models are often not used in many studies. In fact, in modeling studies examining the effects of the model's age on children's motor performance, peer models and adult models are often compared (e.g., Lirgg & Feltz, 1991) rather than peer models and other children of different ages. In many modeling studies involving various other factors (e.g., verbal models, augmented feedback, self-efficacy, etc.) and their effects on children's learning the models, whether they are a correct, learning, or high status, etc., are also most often adults (e.g., Hebert et al., 1994; Wiese-Bjornstal & Weiss, 1992).

Perhaps some of the equivocal findings can be explained in terms of confusion between performance and learning. The similarity between the model and the observer, which includes the model's skill level, status, as well as age and gender, have all been shown to affect performance in modeling situations, however these characteristics have not necessarily been shown to affect learning (McCullagh, Weiss, & Ross, 1989). In a study specifically examining performance and acquisition of a sport skill through modeling with both correct and learning models, while measuring feedback of the model's KR and knowledge of performance (KP), a RT was included to determine learning effects (McCullagh & Meyer, 1997). Results revealed that performance increased with both types of models, as long as feedback was provided. As for learning, the RT results indicated and supported other findings (see *Combining Imagery and Video Modeling*) that modeling has a greater impact on form or technique than on outcome or performance. All groups that received feedback performed better in the RT than the learning model group that did not receive feedback. McCullagh and Meyer acknowledged the need for future research that can help to determine the effectiveness of correct demonstrations with or without feedback.

Or perhaps the findings are equivocal due to the age of the observers. In a review of developmental and psychological factors related to children's modeling of motor skills, Weiss et al. (1993) noted that young learners will attempt to match the model, and therefore the desired outcome and technique must be clearly evident from the demonstration. A skilled model is the important factor, whether it is a high status model (e.g., a teacher) or a peer. These authors further suggested that multiple viewings of a correct model is appropriate, because it will allow the learners to fill in what they may have missed or forgotten from previous viewings. They recognized that it is critical to emphasize to the learner that the quality of observation and practice is more important than quantity. This would imply that shorter, but more frequent and focused modeling and practice sessions with an emphasis on correct technique, and using fewer trials, will hold the attention of the learner.

Combining Imagery and Video Modeling

As discussed in an earlier section (see *Motor skill acquisition and imagery research*), research has shown that imagery can facilitate motor skill performance and, to some degree, acquisition. Similarly, the effects of imagery and observational modeling, and specifically video modeling, on motor skill learning and performance have also been examined. Grouios, Kouthouris, and Bagiatis (1993) studied the effects of mental practice (MP), video-demonstration practice (VDP), physical practice (PP), and no practice (NP) on the learning of skiing skills among novice skiers (mean age unknown). They found that MP had a larger positive effect on the learning of skiing skills than did VDP alone, but that MP and VDP both positively affected the learning of skiing skills.

In one of the few field studies involving children and video modeling, 40 table tennis players (mean age = 8.3 years) were placed into one of three experimental conditions: mental training consisting of relaxation, video observation and mental imagery; video observation only; and physical practice only (Li-Wei et al., 1992). The mental training group improved performance on all four measures from pre- to post-intervention (i.e., two performance accuracy ratings and two technical ratings). The video observation group and the control group showed improvement only on one of the performance accuracy measures, although these were not as large as the mental training group. The results suggest that observing video of high performance players, and then using imagery to recall, recreate, and re-experience the feeling and image of the skilled performers helps young athletes create a more stable and clearer desired image, as well as a stronger and more correct motor pattern (Li-Wei et al.). These researchers suggest that in using video for skill improvement purposes, an effective method for of absorbing the information and integrating it into ones actions (e.g., imagery) is necessary; it is not enough to simply watch a video.

Finally, a study of 9-12 year old tennis players compared three groups: a physical practice only group; a physical practice plus video modeling group; and a physical practice plus video modeling plus imagery group (Atienza et al., 1998). Pre- and post-test measures were taken on accuracy, speed, and technique of a specific tennis serve. The physical practice group showed no differences in accuracy or technique, the physical practice plus video group showed improvement in accuracy and technique, and the physical practice plus video plus imagery group also showed improvement in technique. These results indicate that combining physical training using video-model observation, as well as these along with imagery, produced improvements in technique and subsequent performance.

From the results of these studies it is apparent that video modeling combined with imagery results in both increased physical performance and acquisition of technique.

The Learning and Memory Link - Levels of Processing

Memory is inextricably related to learning; the ability to learn obviously requires memory. Craik and Lockhart (1972) proposed a theoretical framework for memory, levels of processing (LOP), that has since been considered an empirical law of memory (Lockhart & Craik, 1990). The framework, which may be best described as a process-oriented approach to memory (Craik & Lockhart), is based on a single memory system where information processing occurs on a depth continuum from shallow to deep. In cognition, shallow processing refers to physical analysis of a stimulus, and deep processing refers to semantic analysis.

Craik (1973, p.48), defined depth as "the meaningfulness extracted from the stimulus rather than the number of analyses performed upon it." In terms of information retention, retention is a function of depth (Craik & Lockhart, 1972), and it is the variations in the degree of cognitive processing that determine whether something is remembered or not (Craik & Lockhart). Various factors, such as the amount of attention given to a stimulus, as well as the processing time, determine the depth to which the stimulus is processed (Craik & Lockhart). Deeper levels of analysis produce increasingly elaborate, longer lasting, and stronger memory traces (Eysenck & Keane, 2000), and therefore, sustained retention. Conversely, shallow analysis and less elaborate processing produce weaker memory traces, and lead to forgetting.

The LOP framework involves two types of rehearsal that illustrate the distinction between shallow and deep processing: maintenance rehearsal that involves passive repetition of information, and elaborative rehearsal that involves deeper or more meaningful analyses and comprehension of the information (Craik & Lockhart, 1972).

Maintenance rehearsal is a shallow form of processing, a recycling of information in order to keep it available in short-term memory (Craik & Lockhart). Elaborative rehearsal is a more active form of rehearsal where there is a deliberate attempt to cognitively interact with the information to be learned (Craik & Lockhart), and as a result, the stored information is more distinctive (Magill, 1984). Maintenance rehearsal may increase long-term memory, but it does so less than elaborative rehearsal (Eysenck & Keane, 2000), and elaborative rehearsal leads to longer retention than does maintenance rehearsal (Terry, 2003). Many learning strategies, including forming mental images, are instances of the elaborative type of rehearsal (Terry).

Extending LOP into motor skill research. Although LOP studies have mainly been done with verbal learning tasks some researchers have proposed that comparisons between verbal skills and motor skills could be made (Battig & Shea, 1980; Cratty, 1973; Lockhart, 1980; Robazza & Boroli, 1996). Researchers have also agreed that many common principles that underlie memory for verbal material would also underlie all memory, including memory for motor skills (Battig & Shea; Lockhart). An early study involving LOP (delayed retention as a function of depth of processing during initial learning) and motor memory provided support for LOP affecting the initial stages of motor skill learning (Whitehurst, 1981).

With the LOP approach to memory, some implications are apparent: the ability or the memory to reproduce a motor movement will be influenced by the degree to which existing skills are used to structure and perceive meaning in the movement (Lockhart, 1980); longer retention will result if an individual skill is processed in more than one way (Battig & Shea, 1980); and meaningful analysis of a motor movement will be influenced by knowledge drawn by the senses, such as visual-spatial, audio, and touch (e.g., verbal labels, visual, and spatial imagery) (Lockhart).

Memory and children. Among the many developmental issues concerning young children and motor skill learning, both cognitive and memory development are important to consider; cognitive processes, such as information processing, and memory development are inextricably linked (McCullagh et al., 1989). In learning, memory strategies are often used to increase the meaningfulness, and therefore the memorability, of information. In motor skill learning, the use of these strategies (e.g., active rehearsal) is important in developing a knowledge base that can enhance motor control and motor skill execution (Thomas, French, & Humphries, 1986). Not surprisingly, age differences in the capability of information processing and control processes exist (Gallagher & Thomas, 1984). As compared to adults or older children, young children (i.e., under 11-12 years) often fail to use appropriate information processing (e.g., selective attention) or control processes (e.g., labeling and naming, chunking of information, or active rehearsal) (McCullagh et al.; Gallagher & Thomas). Whereas young children generally do not employ these mature strategies deliberately, the ability to use more appropriate or advanced strategies can be manipulated. In a study comparing rehearsal strategies of different age groups (i.e., 5, 7, 11, 19 year olds), Gallagher and Thomas found that when young children rehearsed movement patterns with more advanced or adult-like strategies (i.e., active rehearsal), performance was improved to at least the level of individuals two age groups higher.

Summary

From this review, the following points are central to the study described below: (a) imagery has been shown to facilitate motor performance and acquisition; (b) video modeling can facilitate both motor performance and acquisition; (c) imagery and video modeling combined have a greater effect on learning and performance than physical practice alone; (d) imagery and video modeling research with children in sport is limited, as well as those involving complex motor skill acquisition; (e) the levels of processing framework of memory can be extended into the motor skill domain, and may provide a possible explanation for why imagery and video modeling facilitate skill acquisition; and (f) children have the capability to employ mature memory strategies, and therefore improve performance. What is not clear from the literature, however, is whether imagery and video modeling of a specific complex sport skill by young athletes will have a positive effect on the rate of the physical acquisition of that skill.

Methods and Procedures

This study proposed that imagery and video modeling, used to aid the learning of a new skating skill, influenced the depth of meaning, or analysis, of the skill by the participants (i.e., making comparisons to existing skills, processing information in more than one way, using senses through imagery and video modeling). It was proposed that the imagery and modeling learning condition would create more cognitive and processing effort, thereby creating a stronger memory trace. Thus, longer retention would occur and less number of trials to acquire the new skill would result.

Independent Variable

The treatment condition the participants were assigned to was the independent variable: Condition 1 (Experimental Group; EG) involved MI and VM, along with PP; Condition 2 (Control Group; CG) included only PP.

Dependent Variable

The number of physical attempts made of the experimental skill (Inside Axel Paulsen; defined below in *The Skill*, pp. 29-30) until the participants successfully completed 4 out of 5 successive jumps at the required minimum criteria.

Secondary Variables

Six secondary variables for each of the 8 days were also included: (a) the total number of falls; (b) the total number of attempts made; (c) the total number of successfully completed jumps; (d) the total number of attempts that had the correct take-off, but were not landed; (e) the total number of attempts that were rotated and landed, but had a small error on the take-off; and (f) the total number of attempts that were successfully landed, but were a different jump altogether (i.e., Loop jump).

Feedback

Augmented, verbal feedback was purposively excluded from the study. While the importance of augmented feedback in learning was realized, to control for as many variables as possible, feedback was not shared between the researcher and the participants during the study. This delimitation was expected to have a negative effect on the rate of acquisition of the skill, but by not providing feedback, the physical practice sessions remained consistent for all participants.

Limitations

The most significant limitations of the study were the small total number of participants and the missing data due to absent participants. Other limitations of this study included: one less treatment session than originally proposed due to extraneous commitments of one of the skating schools; participants who appeared not to use the full practice time for quality practice; participants in the Control Group who may have used spontaneous MI that was unaccounted for; possible contamination of the experiment by participants in one group speaking to participants in another group about their intervention; the videos not capturing all attempts clearly; participants physically practicing the skill at times other than during the study's monitored physical practice sessions; participants' abilities increasing or decreasing caused by outside factors; as well as differences in the participants' motivation (e.g., intrinsic motivation, motivational climate of the schools).

Participants

The participants were 16 volunteer figure skaters, 1 boy and 15 girls. All participants were Preliminary Freeskate level skaters, had no previous experience with the treatment skill to be learned, and were members at one of two skating schools. The participants were purposively selected and assigned to two groups (see *Purposeful assignment*, below). The groups were randomly assigned to 1 of 2 conditions: the Experimental treatment (EG, n = 8) and the Control treatment (CG, n = 8). The participants ranged in age from 7 to 12 years, with a mean age of 9. The two groups were matched for age, EG (M = 10.0; SD = 1.85) and CG (M = 9.25; SD = 1.17), with no statistically significant difference between the groups for age, $t(14) = .97, p > .05$.

Participant selection. Participants were selected based on age, current ability, and location. The age range of 7-12 years was chosen as most skaters leave group-type lessons and begin taking one-on-one lessons with a coach at this time in their skating development, and therefore begin to progress more rapidly. Also, this is a critical age for children in regards to cognitive and memory development (Gallagher & Hoffman, 1987). Children in this age range are in a stage where they are developing the ability to use advanced cognitive and memory strategies (Gallagher et al., 1984). Also, this age range was similar to the ages of participants of other imagery and modeling studies done within youth sport (e.g., Atienza et al., 1998; Li-Wei et al., 1992).

In regards to ability, the participants had not passed any Skate Canada freeskate tests, but were able to complete all single jumps, excluding a single Axel jump. This level of ability was chosen in consideration of the degree of difficulty of the skill to be learned in the study, the Inside Axel Paulson (Inside Axel) jump (i.e., the Inside Axel is more difficult than the single jumps the participants were already capable of, but less difficult than the single Axel jump). Further, none of the participants had received coaching specific to the Inside Axel or had seen it performed on a regular basis.

Two similar skating schools were selected, with each group situated at its own school. The skating schools were chosen on the basis of their similarity: the schools' membership numbers were comparable; the coaches at both schools had similar coaching experience and certification; the amount of ice time for the figure skating programs were similar; and both clubs trained skaters competing at the Provincial A level or higher.

Purposeful assignment. To control for possible contamination of the experiment (e.g., participants speaking to each other about the intervention, spontaneous mental rehearsal of the skill by the CG as a result of seeing participants from the EG's physical practice session), participants were purposively assigned to their experimental treatment based on location. To account for any findings that may occur due to this purposeful assignment, a test designed to measure athletes' imagery ability (MIQ) was administered to all participants before and after the study.

The Skill

The skill taught was the Inside Axel jump. This figure skating jump is listed in the Skate Canada rulebook as a legal jump, but is not commonly practiced or seen in competition. The participants had minimal or no previous exposure to the skill, therefore, the skill was considered novel. The Inside Axel is a unique jump that requires take-off from a forward inside edge, one and one half revolutions in the air, with the landing on a backward outside edge of the normal landing foot. The takeoff and landing are completed on the same foot. This jump shares some commonalities to the other jumps the participants had prior experience with (e.g., direction of rotation; landing foot and air position). The jump is unique in that the forward inside take-off edge is not used in any other jump take-off and this, along with the extra rotation, increases the difficulty of the jump.

The Models

Multiple mastery models, who were close in age to the participants, were chosen to demonstrate the Inside Axel. The models, one male and one female, were amateur skaters, who could successfully execute the Inside Axel. The models were within 5 to 7 years of the participants' age (i.e., 14 years old). The models' demonstrations were captured on videotape.

Design

The study took place over six consecutive weeks during the winter skating season, and included seven 30-minute sessions of the prescribed condition spread over the six weeks, and one 15-minute session on the eighth day. This last session was considered a RT. Each participant's total time commitment was 4 hours and 45 minutes, including the RT, the pre-test on-ice assessment, and the administration of the two MIQs.

Intervention/Teaching of the Skill

Each group completed a total of seven sessions with the researcher, as well as one on-ice RT. Each of the seven sessions included an off-ice (15 minutes) and an on-ice component (15 minutes), lasting for a combined total of 30 minutes. The RT consisted of only the on-ice portion, and lasted 15 minutes. Throughout the study, each group had an equal amount of contact with the researcher.

Off-ice sessions. The off-ice portion immediately preceded the on-ice portion (see Table 1 for complete off-ice procedures). Participants wore their skates during the off-ice sessions for time efficiency, and to ensure that the EG group's imagery would be done in as close of a physical feeling as possible as being on ice.

Table 1

Off-Ice Procedures

Group	Description
Experimental Group	1) Viewing of the 5-minute video (video modeling), while the main points (i.e., the take-off, air position, landing, and speed) of the Inside Axel were outlined by the researcher.
	2) 1 minute of mental imagery (MI) specific to the Inside Axel jump, guided by the researcher (Appendix B).
	3) 1 minute of self-guided MI. Participants were asked to imagine seeing and feeling themselves performing the Inside Axel successfully. They were reminded that any combination of internal or kinesthetic imagery was acceptable and were encouraged to use each type of imagery during both the VM and MI portions.
	4) Viewing of the 5-minute video. Participants were asked to use MI to imagine and feel themselves skating in place of the models, or along with the models.
Control Group	1) A 5-minute warm-up consisting of running on the spot, in the hallway, and rope-less skipping.
	2) 10-minute major muscle group stretches, guided by the researcher.

On-ice sessions. Each group participated in virtually identical on-ice physical practice (PP) sessions (see Table 2 for complete on-ice procedures). These sessions were fifteen minutes in length, and were consistent for the duration of the study. The RTs followed this procedure as well.

Table 2

On-Ice Procedures

Group	Description
Experimental and Control Groups	1) Participants were reminded that the entire 15-minute period (warm-up and practice time) would be videotaped by two video cameras.
	2) Participants skated a timed 4-minute general on-ice warm-up, where they warmed-up with any skills they chose, excluding physical practice of the experimental skill.
	3) Participants were called to the side of the ice where they viewed the 1-minute video. The video was shown once, during which the main points of the skill were described by the researcher.
	4) The researcher gave the participants definitions for the minimum criteria for successfully completed jumps (see Appendix C), and attempts (e.g., aborted attempts, successful attempts).
	5) Participants were instructed: that the goal for the session was to complete the jump to the minimum criteria 4 out of 5 times, and in as few attempts as possible; that any attempt of the jump would be counted as a practice trial; that they should make as many attempts in the ten-minute practice period as they were comfortable to do; that they may skate at any speed at which they felt comfortable, rest at anytime, and utilize the entire available ice surface; to use the entire ten minutes and; to not speak with any of the other participants or the researcher during the session.
Experimental Group	6) Participants were asked to use MI throughout the on-ice portion.
Experimental and Control Groups	7) At the conclusion of 10 minutes, participants were called over to the side of the ice, thanked for their participation, reminded about the next session and that they were expected not to practice the Inside Axel outside of the study in any way.
Experimental Group	8) Participants indicated imagery use during the practice, according to the scale, in a Mental Imagery Log.

Apparatus

Electronic equipment. A digital video camera (Sony Digital Handycam DCR-TRV510) on a tripod was used to record the models demonstrating the desired skill level, and two video cameras (1 Sony Digital Handycam DCR-TRV510 and 1 Sony Vision Handycam CCD-TRV93) on tripods were used to record the participants' warm-up and jump attempts throughout the study. A portable television and Video Cassette Recorder (VCR) unit (Toshiba TV/VCR Combo MV13DL2 13") was used to show the videos to the participants. A VCR (Sansui VCR7000C) and a television (Zenith SY1953Y 24") were used in the analysis of the videotaped practice sessions. A stopwatch was used to time the on-ice and off-ice sessions.

Videotape of the experimental skill. Two videotapes depicting the two models demonstrating the experimental jump were used: a 5-minute video and a 1-minute video. The video depicted the models performing the skill at varying speeds (i.e., initially from a standstill, then at medium speed, and finally at performance-level speeds), with slow-motion sections that highlighted key points in the jump. The 1-minute video was a shortened version of the 5-minute video, and included the same slow-motion section as the 5-minute video. In both videos, the models were seen from various angles.

Questionnaires. Two questionnaires were used in the study: a demographic information questionnaire, and the Mental Imagery Questionnaire (MIQ; Hall & Pongrac, 1983). The questionnaires were administered to the participants in private settings. The demographic questionnaire and one MIQ were given at the beginning of the study and a second MIQ was done at the completion of the study.

Record sheets. The following record sheets were used: Pre-study Assessment of Skating Ability, Mental Imagery Log, Record of Number of Attempts, and Retention Test Number of Attempts.

Procedure

The researcher contacted coaches at two skating schools in the local area and the requirements and outline of the study were explained. The coaches' permission to approach possible participants was required, as well as consent to use their clubs' ice time. The coaches agreed to allow the researcher to approach skaters matching the criteria for the selection of participants and these skaters were asked if they would like to participate in the study. Seventeen of these skaters fit the criteria for the study, 8 at one school and 9 at the other, however, one of the EG participants only attended 3 of the 7 treatment days. The three days of results from this participant, as well the scores from the pre-study evaluation and MIQ, were not included in the analysis. As the participants were under 18 years of age, participants and their parents or guardians were given information about the study, parental and informed consent forms (Appendixes D, E), and questionnaires requesting demographic information about the participants. The on-ice portions of the study were conducted with other skaters not involved in the study on the ice. These skaters received a notice informing them that they may inadvertently be videotaped, but no attempt would be made to analyze these inadvertent appearances (Appendix F).

A qualified Skate Canada Intermediate Level Figure Skating Evaluator conducted an on-ice assessment of the participants' skating ability the week prior to the start of the intervention sessions. The evaluator followed the standards set by Skate Canada in regards to a Preliminary Freeskate test (Skate Canada, 2002), with the addition of a Toe Loop, Lutz, and Axel jump to the test. To ensure that the participants had no previous experience or training of the experimental skill, participants were asked if they have received coaching to learn the Inside Axel, or if they have seen others regularly practicing the jump.

The MIQ was administered to all participants two days before the study began at their respective schools, and then again on the last day of the study following the on-ice RT.

All participants were asked to follow the specific interventions as directed and to keep the intervention confidential until the completion of the study. Participants received a schedule that outlined the dates for their sessions. Each group's intervention was scheduled within a period of four consecutive weeks and consisted of seven off- and on-ice sessions, as well as an eighth on-ice only session for the RT.

Data Collection

Data were compiled from the pre-study on-ice assessment of the participants' skating ability, pre- and post-study MIQ scores, a mental imagery log, as well as from the videotapes of the PP, and on-ice retention sessions. The videotape data were the major focus of the analysis.

Observers. A certified Intermediate Test Level Skate Canada figure skating evaluator conducted the initial on-ice assessment of the participants' ability. One other independent observer, a NCCP Level 3 certified professional figure skating coach, aided the researcher in standardizing and defining the criteria for skill attempts, and those for the successful completion of a jump. This coach also was consulted in devising and operationalizing the script of instructions for the Inside Axel and acted as a second rater, viewing 25% of the videotaped PP sessions to assess the researcher's accuracy in coding the PP sessions. The PP sessions the observer viewed and coded were chosen randomly, and the observer was trained for the coding with four of the remaining sessions.

The two observers were blind to the groups' conditions, and were not involved with the participants in any way other than for the purpose of this study (i.e., were not employed by or volunteers at either of the skating schools involved in the study, and were not related to the participants in any way).

Video of practice sessions. To assess the number and content of physical attempts made by each participant accurately, the PP sessions were videotaped. Two cameras were used, positioned at different vantage points, ensuring that the entire practice area was visible, and that no attempts were missed.

Record sheets. Record sheets were used to track the following data for each participant each day: the total number of attempts made; the total number of attempts until the jump was landed for the first time; the total number of successfully completed jumps; how many jumps were landed successfully 4 out of 5 times; as well as the total number of attempts that had the correct take-off; the total number of attempts that were rotated and landed, but had a small error on the take-off; the total number of attempts that were actually a different jump altogether (i.e., Loop jump); and the total number of falls. The record sheets were used to track the number of physical attempts of each variable made by the groups. Subjective measurements or judgments about the quality of the attempts were not made.

Mental imagery use log. A log was kept for each of the EG participants to track imagery use during the PP sessions. This was a self-report log, based on a simple 5-point scale, which indicated how often the participants employed imagery during the PP sessions. This information was collected at the end of the PP sessions. Specifically, participants were asked to rate the approximate number of times they used imagery for attempts (i.e., before, in between, or after attempts) during the on-ice session, based on the following scale: 1 = not at all, 2 = more than once, but for less than half of the attempts, 3 = for half of the attempts, 4 = for more than half of the attempts, but not all of them, 5 = for every attempt.

Results

Data were compiled, from the seven PP sessions and the RT, for the dependent variable: the number of attempts required to learn the Inside Axel jump (i.e., consistently complete the jump successfully four out of five times in succession), as well as for six secondary variables: the number of attempts made; the number of falls; the number of successfully completed jumps; the number of attempts made with the correct take-off, but not successfully completed; the number of attempts with a small error on the take-off, but were successfully completed; and the number of attempts made with an incorrect take-off, but successfully completed (i.e., a Loop jump).

Each day had a varying amount of participants. To fairly compare the results for each group after the same number of exposures to the treatment condition, the data from each chronological 'treatment' day was transferred to 'practice' days. For example, if a participant was present for Days 1, 2, 3, 5, 6, 7, but not for Day 4, the data collected on Days 5, 6, 7 were moved to Practice Days 4, 5, 6, with the seventh day showing no data. This way, each participant's Day 5, for example, would be compared to the other participants' Day 5, and all would have received the same number of exposures to the treatment condition at that point. All participants attended the final day, which was the RT (i.e., PP only). The data from the RTs were not transferred into practice days as above, since the participants did not receive an off-ice session that day (i.e., this day was different from the others).

The number of attempts made by each participant may have had an effect on the outcome of each participant (e.g., it was assumed that a participant making 50 attempts would have a greater chance of successfully completing the skill more times than a participant who only made 15 attempts). Therefore, the data collected for the secondary variables were corrected for the total number of attempts made each day, which allowed for equal comparisons to be made.

Pre-study evaluation. Independent samples *t* tests were completed for each of the 14 skills as outlined in Skate Canada's Preliminary Freeskate Test Part 1, plus 3 additional skills, the Toe Loop, Lutz, and Axel jumps, which were included as further measures of skill level. A statistically significant difference between the groups was found on one skill, the Toe Loop jump, $t(14) = 2.90, p = .01$ (see Appendix G).

MIQ scores. The alpha level was set at .05 for all MIQ analyses. The total mean scores of the pre- and post-study MIQ were compared between groups and within groups. A *t* test for independent samples, conducted to compare the mean total scores between groups (see Appendix H, Table A1), found no statistically significant differences. Paired samples *t* tests were used to compare the means of the pre- and post-study MIQ scores within groups and no statistically significant differences were found (see Appendix H, Table A2). To confirm that a two-way interaction was not occurring, the differences between the pre- and post-study total scores for each participant were calculated and compared with a *t* test for independent samples (see Appendix H, Table A3). The differences were not found to be statistically significant, and this indicated that an interaction effect had not occurred.

Between group and within group analyses were also conducted on the two separate components of the MIQ, visual and kinesthetic movement imagery. The pre- and post-study mean scores on these components were compared for each group with *t* tests for independent samples and no statistically significant differences were found (see

Appendix H, Table A4). The within group analysis was conducted with *t* tests for paired samples (see Appendix H, Table A5). The EG showed no statistically significant difference in their pre- and post-study mean scores for either visual or kinesthetic movement imagery. The CG showed no statistically significant difference for visual imagery, but did have a statistically significant difference for kinesthetic imagery, $t(7) = 2.52, p = .04$.

Video analysis. To ensure the accuracy of the video data recorded and coded by the researcher, a second rater viewed 25% of the eight sessions. The inter-rater reliability was 0.92.

Mental imagery use log. The means and standard deviations were calculated for the EG's daily, self-reported imagery use during the PP sessions (see Table 3). The EG consistently used imagery in the PP sessions, throughout the study.

Performance Data

The raw data showed that no participant completed the Inside Axel to the minimum performance criteria of 4 out of 5 times (80%) consecutively. In fact, only one participant completed the jump 1 to 2 times out of every 5 attempts (20% to 40%), and only on 2 of the 6 practice days this participant attended. Six participants, 3 from each group, successfully completed the jump to the performance criteria, but none consistently or consecutively 4 out of 5 times. Therefore, according to the criteria set a priori, the Inside Axel was not considered as 'learned' by any of the participants.

Table 3

Means and Standard Deviations for the EG's Self-Reported Daily Use of Mental Imagery

Practice Day	*M*	*SD*	*n*
1	3.38	1.19	8
2	2.75	1.49	8
3	3.13	0.64	8
4	2.38	1.19	8
5	2.25	1.04	8
6	1.83	1.17	6
7	3.50	0.58	4
RT	2.88	0.99	8

Descriptive and Inferential Statistics

The groups' data for each of the six secondary variables, on each of the practice days and the RT, were compared with both descriptive and inferential analyses. In consideration of the small sample size, it was valuable to examine the descriptive statistics to illuminate apparent trends and the means and standard deviations of these variables were compared. One-Way Analyses of Variance (ANOVA) were used to compare the means of the two groups to uncover any statistically significant differences that might exist. The probability of a Type – 1 error was set at .05 but, due to the small number of participants, it was judged that results significant at the .1 level were notable as well.

Number of attempts. The descriptive statistics suggested that the EG averaged fewer attempts per day than the CG, with the exception of day 6. Both groups were relatively consistent in the average amount of attempts they made each day, as seen in Table 4 (EG ranged from 37 to 47; CG ranged from 38 to 56). Table 5 revealed that no statistically significant difference was found between the groups on this variable.

Table 4

Means and Standard Deviations for the Number of Total Attempts Made by Group per Day

	Group					
Practice Day	Experimental			Control		
	M	*SD*	*n*	*M*	*SD*	*N*
1	46.88	9.14	8	56.25	14.30	8
2	37.00	10.88	8	46.50	15.69	8
3	42.50	15.65	8	50.50	18.23	8
4	45.13	17.72	8	49.00	15.54	8
5	42.38	8.26	8	43.50	8.90	8
6	45.33	14.60	6	38.00	14.00	5
7	41.75	6.29	4	48.50	14.85	2
RT	39.53	10.98	8	44.63	15.11	8

Number of falls. The descriptive statistics suggest that, on average, the EG group made fewer falls than the CG (see Table 6). The EG's percentage of falls ranged from 2% to 9% of the attempts made, whereas the CG ranged from 6% to 16%. The EG's number of falls fluctuated over the eight days, while the CG's number of falls remained relatively consistent, with the exception of Practice Day 5. As seen in Table 7, statistically significant differences were found between the groups on Practice Day 5, $F(1, 14) = 3.72$, $p = .07$, and during the RT, $F(1, 14) = 4.59, p = .05$.

Table 5

Analysis of Variance for Total Number of Attempts per Day

Practice Day	$df_{between}$	df_{within}	F	MS	P
1	1	14	2.44	144.03	.14
2	1	14	1.98	182.29	.18
3	1	14	.89	288.57	.36
4	1	14	.22	277.63	.65
5	1	14	.07	73.71	.80
6	1	9	.71	205.48	.42
7	1	4	.72	84.81	.45
RT	1	14	.57	174.41	.46

Number of successfully completed jumps. The descriptive statistics (see Table 8) suggest that 6 participants, 3 from each group, completed the jump successfully (i.e., correct take-off, correct amount of rotation, and correct landing). The EG participants who completed the jump, did so more often (completed jumps on 7 of the 8 days, ranging from 1.3% to 4.2% of the attempts made) than the CG (completed jumps on 3 of the 8 days, but less than 1% of the attempts were successful). There was a positive general trend for the EG, who increasingly completed more attempts, as the study progressed. No attempts were completed by the EG on Practice Day 7. The raw data showed that of the 3 participants who successfully completed the jump only 1 was present on Practice Day 7 and that 89% of this participant's attempts were made as another error (i.e., with a small error on take-off, but successfully completed). The general trend for the CG was also positive until Practice Day 5. After Day 5, no attempts were completed successfully by the CG, and the number of attempts of other types of errors increased (i.e., Landed successfully, but with small error on take-off, and Landed successfully, but with incorrect take-off: Loop Jump). No statistically significant differences were found between groups for the number of successful jumps completed (see Table 9).

Table 6

Means and Standard Deviations for the Number of Falls by Group per Day

Practice Day	Group					
	Experimental			Control		
	M	*SD*	*n*	*M*	*SD*	*n*
1	.04	.05	8	.09	.09	8
2	.07	.08	8	.12	.17	8
3	.06	.08	8	.12	.14	8
4	.09	.09	8	.12	.10	8
5	.03	.03	8	.06	.04	8
6	.07	.06	6	.16	.17	5
7	.0	.07	4	.12	.05	2
RT	.02	.02	8	.11	.108	8

Table 7

Analysis of Variance for Number of Falls per Day

Practice Day	$df_{between}$	df_{within}	*F*	*MS*	*p*
1	1	14	2.04	.01	.18
2	1	14	0.61	.02	.45
3	1	14	1.01	.02	.33
4	1	14	.39	.01	.54
5	1	14	3.72	.00	.07*
6	1	9	1.95	.01	.20
7	1	4	1.47	.01	.29
RT	1	14	4.59	.01	.05**

$*p < .1$. $**p < .05$.

Number of attempts made with the correct take-off, but not successfully completed. The descriptive statistics (see Table 10) suggest that the EG showed a positive general trend over time, in the amount of correct take-offs, while the CG showed a slightly negative general trend. The EG became better at doing correct take-offs, and the CG became worse. However, no statistically significant differences were found between the groups on this variable (see Table 11).

Number of attempts with a small error on the take-off, but successfully completed. The descriptive statistics suggest that the number of attempts with this error increased in both groups over time. The EG's positive increase was moderate, and increased by 19%, from Practice Day 1 to Practice Day 7 (see Table 12). The CG's positive increase was steeper, and increased by 40%, from Practice Day 1 to Practice Day 7. Practice Day 1 scores for the EG revealed that 32% of the attempts made were with this type of error, and at the RT, this percentage remained at 32%. The CG, on the other hand, recorded 4% of attempts having this error on Practice Day 1 and 35% on the RT.

Statistically significant differences were found between the groups for attempts completed with this error on the take-off on Practice Days 1 and 2, $F(1, 14) = 4.88, p = .04$; $F(1, 14) = 5.56, p = .03$, and on Practice Days 3 and 4, $F(1, 14) = 3.35, p = .09$; $F(1, 14) = 3.35, p = .09$ (see Table 13).

Table 8

Means and Standard Deviations for the Number of Attempts Successfully Completed by Group per Day

Practice Day	Group					
	Experimental			Control		
	M	*SD*	*n*	*M*	*SD*	*n*
1	.017	.048	8	.000	.000	8
2	.021	.040	8	.004	.010	8
3	.042	.110	8	.000	.000	8
4	.020	.037	8	.006	.012	8
5	.041	.085	8	.009	.018	8
6	.013	.032	6	.000	.000	5
7	.000	.000	4	.000	.000	2
RT	.063	.139	8	.000	.000	8

Number of attempts with incorrect take-off, but successfully completed (i.e., a different jump: Loop jump). The descriptive statistics, as seen in Table 14, depict the EG as showing a steep negative trend in the number of attempts with this type of error, with the exception of the RT (Day 1 = 24% to Day 7 = 13%, and RT = 21%). The CG consistently performed more attempts of this type of error than the EG, but in decreasing amounts over the eight days as well. The CG's negative trend was moderate (ranging from Day 1 = 40% to Day 7 = 3%, and RT = 34%). No statistically significant difference was found for the number of Loop jumps performed by the groups (see Table 15).

Table 9

Analysis of Variance for Number of Successfully Completed Attempts per Day

Practice Day	df_{between}	df_{within}	*F*	*MS*	*p*
1	1	14	1.00	.00	.33
2	1	14	1.52	.00	.24
3	1	14	1.14	.01	.30
4	1	14	1.05	.01	.32
5	1	14	1.05	.00	.32
6	1	9	.82	.00	.39
7	1	4	-	.00	-
RT	1	14	1.64	.01	.22

Table 10

Means and Standard Deviations for the Number of Attempts With Correct Take-Offs, but Not Successfully Completed by Group per Day

Practice Day	Group					
	Experimental			Control		
	M	*SD*	*n*	*M*	*SD*	*n*
1	.11	.17	8	.25	.39	8
2	.27	.40	8	.42	.45	8
3	.30	.37	8	.23	.34	8
4	.22	.33	8	.19	.25	8
5	.27	.35	8	.22	.29	8
6	.35	.42	6	.21	.39	5
7	.22	.40	4	.22	.29	2
RT	.25	.33	8	.14	.29	8

Table 11

Analysis of Variance for Number of Attempts with Correct Take-off, but Not Successfully Completed per Day

Practice Day	$df_{between}$	df_{within}	*F*	*MS*	*p*
1	1	14	.93	.09	.35
2	1	14	.51	.18	.49
3	1	14	.18	.13	.68
4	1	14	.02	.08	.90
5	1	14	.10	.10	.76
6	1	9	.23	.17	.64
7	1	4	.00	.14	1.0
RT	1	14	.52	.10	.48

Table 12

Means and Standard Deviations for the Number of Attempts with a Small Error on Take-off, but Successfully Completed by Group per Day

Practice Day	Group					
	Experimental			Control		
	M	*SD*	*n*	*M*	*SD*	*n*
1	.32	.35	8	.04	.08	8
2	.35	.40	8	.02	.04	8
3	.26	.33	8	.04	.07	8
4	.48	.44	8	.11	.16	8
5	.41	.41	8	.17	.23	8
6	.43	.43	6	.27	.34	5
7	.51	.48	4	.44	.62	2
RT	.32	.39	8	.35	.40	8

Table 13

Analysis of Variance for Number of Attempts with a Small Error on Take-off, but Successfully Completed per Day

Practice Day	$df_{between}$	df_{within}	*F*	*MS*	*p*
1	1	14	4.88	.07	.04**
2	1	14	5.56	.08	.03**
3	1	14	3.35	.06	.09*
4	1	14	3.35	.11	.09*
5	1	14	2.00	.11	.18
6	1	9	.46	.15	.51
7	1	4	.02	.27	.87
RT	1	14	.03	.16	.87

* $p < .1$. ** $p < .05$.

Table 14

Means and Standard Deviations for the Number of Attempts with Incorrect Take-off, but Successfully Completed (i.e., Loop Jumps) by Group per Day

	Group					
Practice Day	Experimental			Control		
	M	*SD*	*n*	*M*	*SD*	*n*
1	.24	.36	8	.40	.36	8
2	.25	.39	8	.33	.37	8
3	.20	.34	8	.36	.37	8
4	.18	.34	8	.31	.37	8
5	.19	.31	8	.35	.39	8
6	.07	.16	6	.04	.35	5
7	.13	.26	4	.03	.37	2
RT	.21	.37	8	.35	.36	8

Table 15

Analysis of Variance for Number of Attempts with Incorrect Take-off, but Successfully Completed (i.e., Loop Jumps) per Day

Practice Day	df_{between}	df_{within}	*F*	*MS*	*p*
1	1	14	.86	.13	.37
2	1	14	.20	.15	.66
3	1	14	.90	.13	.36
4	1	14	.52	.12	.48
5	1	14	.88	.13	.37
6	1	9	.19	.02	.67
7	1	4	.28	.05	.63
RT	1	14	.52	.14	.48

Discussion

Pre-Study Evaluation

This evaluation was based on a rating scale that consisted of four scores: Excellent (E); Good (G); Satisfactory (S); and Needs Improvement (NI). Participants were required to obtain an S score, or higher, for a minimum of 14 skills, including the Toe Loop and Lutz, but not the Axel. A statistically significant difference was found between the groups for the Toe Loop jump. Further examination of this skill in the raw data, however, revealed that 6 of the 8 EG participants scored a rating of good (G) or higher, whereas only 1 of the 8 CG participants scored G or higher; all other participants scored satisfactory (S). Therefore, although the *t* test showed a significant difference statistically, all participants scored a minimum of S on this skill, which met the original criteria. Further, all participants received the minimum score of 14 satisfactory ratings or higher and, therefore, were found to have similar skating ability (i.e., Preliminary Freeskate test level skaters; unable to land a single Axel jump).

MIQ Scores

MIQ scores were recorded for both groups before and after the study to track the participants' ease in using mental imagery, and to monitor potential changes in imaging ability during the study. The means of the total scores were compared, both between groups and within groups, to determine if the results of the study were simply reflections of pre-existing imagery ability or changes in movement imagery ability. Further, pre- and post-study mean scores for the two components of the MIQ, visual and kinesthetic movement imagery, were compared between groups and within groups.

The pre- and post-study MIQ total mean scores indicated that the EG and the CG were not significantly different from each other statistically, before or after the study. Both groups scored lower in the post-study MIQ, indicating that the participants reported imaging to be easier after the study, and that imaging ability increased. The difference in the EG's pre- and post-study totals were approaching statistical significance. This difference was attributed to the MI portion of the treatment; the EG engaged in imagery more extensively than the CG and it was plausible that EG's scores would reveal a larger increase in their ability to image.

The CG's improvement in imaging ability was smaller, and was attributed to their increased awareness of MI, due to the administration of the MIQ tests. Further, the CG may have used MI spontaneously, as they had been introduced and potentially alerted to its uses through the administration of the MIQ.

The between groups' pre- and post-study visual and kinesthetic movement imagery scores indicated that the EG reported that visual imagery became easier, whereas the CG reported that visual imagery became more difficult. Both groups' scores for kinesthetic movement imagery indicate improvement in the ability to 'feel' images. The within group analysis for the pre- and post-study visual and kinesthetic movement imagery revealed expected, but statistically insignificant, improvements for the EG group on both components. The CG's pre- and post-study analysis, showed a small improvement for the visual component, and a statistically significant difference for the kinesthetic component. This large improvement in the CG's reported kinesthetic imagery ability was unexpected and unexplained.

Mental Imagery Log

The EG's imagery log showed that imagery was used in all PP sessions. The log was based on a rating scale from 1 to 5, and participants rated the number of times they used imagery each day. For 4 of the days, including the RT, the EG reported using imagery for half of the attempts made, and for the remaining 4 days they reported using imagery for more than none, but less than half, of the attempts made.

Performance Data

No participant was able to learn the Inside Axel to the study criterion of successfully completing 80% of the attempts made. It was apparent that the goal of achieving this criterion in seven practices was too stringent. The timeline was too short and created questions about whether or not the Inside Axel could be learned by skaters at the Preliminary Test level, without either more time or some form of augmented feedback. The central hypothesis of the study, that using video modeling and mental imagery to aid the learning of a new skating skill through providing more cognitive depth, thus resulting in greater retention, and ultimately reducing the rate of learning a new skating jump, was not entirely supported. The descriptive analysis, however, showed positive effects for the MI+VM treatment.

Descriptive and Inferential Statistics

The groups' means and standard deviations for the 6 secondary variables were analyzed to capture any potentially distinctive trends, and to learn what the groups did consistently, from Practice Day 1 through to the RT. Inferential statistics, in the form of One-Way ANOVAs, were also conducted for further analysis. The results of the descriptive analysis, and where applicable, that of the inferential analysis, for the secondary variables are discussed and summarized below.

Number of attempts. Overall, the descriptive statistics show that the EG made fewer attempts than the CG and that both groups remained consistent in the average amount of attempts they made each day. It is reasonable to assume that the EG made fewer attempts, on average, owing to their instructions to use MI between attempts throughout the PP session. It is assumed that the imagery use caused the EG to make more 'thoughtful' attempts, took more time than if they had not been employing MI, and resulted in fewer attempts each day than the CG. Each group received consistent instructions before each PP session, and it was not surprising to find that the number of attempts made by each group remained consistent throughout the study.

Number of falls. The descriptive analysis shows that, on average, the EG group made fewer falls per day than the CG, which was an anticipated outcome. It is reasonable to suggest that the EG fell less, due in part, to their imagery use during the PP sessions; the EG made more 'thoughtful' attempts, were more familiar with the jump through the MI and VM, and, therefore, fell less often. The EG's percentage of falls ranged from 2% to 9% of the attempts made, where the CG ranged from 6% to 16%.

The EG's number of falls varied more than the CG's; the CG's daily average for falls remained fairly stable with the exception of Practice Day 5, which showed a mean of 6%, and was lower than the other days. The raw data showed that on Day 5, two of the participants, CG1 and CG7, who usually fell on 20% to 30% of their daily attempts, or higher, fell only on 13% and 10% of their attempts, respectively. These participants' low number of falls, accounts for the sharp decrease in the CG's falls on Day 5, but it is interesting to note that on Day 6 and the RT, participant CG1 resumed a high percentage of falls, 39% and 32% respectively (participant CG1 was absent for day 7), whereas participant CG7 did not make any falls during the RT (participant CG7 was absent for Days 6 and 7).

Both groups fell less during the RT, which may have been attributed to the participants trying harder to successfully complete their attempts, or at least land upright, on the last day. Further, statistically significant differences were found for the number of falls, on Practice Day 5, $F(1, 14) = 3.72, p = .07$ and on the RT, $F(1, 14) = 4.59, p = .05$.

Number of successfully completed jumps. Six participants in total completed the Inside Axel successfully (i.e., correct take-off, correct amount of rotation, and correct landing). The descriptive statistics show that the 3 EG participants who completed the jump did so more often (completed jumps on 7 of the 8 days, ranging from 1.3% to 4.1% of the attempts made) than the 3 CG participants (who completed jumps on 3 of the 8 days, but less than 1% of the attempts were successful).

There was a positive general trend for the EG, who showed an increase in number of successful attempts, as the study progressed. No attempts were successfully completed by the EG on Practice Day 7. The raw data revealed that of the 3 EG participants who successfully completed the jump, only 1 was present on Practice Day 7, and that 89% of this participant's attempts were made as another error (i.e., small error on take-off, but successfully completed). It is likely that this participant was not aware of the subtle error made on the take-off and believed that these attempts were successfully completed as they were landed with the correct landing components (i.e., backwards, on the correct foot, and not falling). If given some form of augmented feedback to correct this small error on the take-off, it is likely that this participant would have been more successful in correctly completing more of these attempts.

The general trend for the CG was also positive until Practice Day 5. After Day 5, no attempts were completed successfully by the CG, and the number of attempts made with other types of errors increased (i.e., landed successfully, but with small error on take-off, and landed successfully, but with incorrect take-off: Loop jump).

Number of attempts made with the correct take-off, but not completed. As seen in the descriptive statistics, the amount of attempts with this error increased over time for the EG, and decreased for the CG. This finding was attributed to the MI and VM received by the EG; the EG was consistently exposed to more correct take-offs via MI and VM, whereas the CG had limited experiences of seeing this specific portion of the jump completed correctly. It would be expected that the EG would recognize the importance of the take-off, before the CG would.

Number of attempts with a small error on the take-off, but successfully completed. This error, often only perceptible in slow-motion analysis, was considered minor and was the type of attempt made that most closely resembled the Inside Axel (see Appendix C for a description of this error). The descriptive analysis suggested that the number of attempts made with this error increased in both groups over time; the CG's positive increase was steep, whereas the EG group's increase was modest. The CG had less exposure to correct demonstrations of the Inside Axel and, therefore, a more unclear understanding of the required take-off than the EG. The EG group had more exposure to correct demonstrations, and acquired a more precise understanding of the correct take-off. Further, the EG had the opportunity to image and process the correct take-off as early as Practice Day 1. These factors attributed to the larger percentage of this type of error by the EG, even for the first PP session.

Both groups appeared to understand that a backward landing indicated a completed jump but it was, perhaps, less obvious to the CG that a forward take-off was also necessary. Participants in both groups were rotating and landing these attempts backwards but without specific, external feedback about the subtle error on the take-off, they likely believed that they were correctly completing the jump, and continued to increasingly commit this error, although to differing degrees.

Statistically significant differences were found between the groups for the number of attempts made with this error on Practice Days 1, 2, 3, 4 [$F(1, 14) = 4.88, p = .04$; $F(1, 14) = 5.56, p = .03$; $F(1, 14) = 3.35, p = .09$; $F(1, 14) = 3.35, p = .09$]. This difference indicated that the EG and CG became more alike, in the number of attempts made with this error, as the study progressed. Both the descriptive and inferential analyses indicate that both groups became better at making attempts that were most like the Inside Axel.

Number of attempts with incorrect take–off, but successfully completed (i.e., Loop jump). This error was considered larger than the attempts made with a small error on the take-off, but completed successfully. Attempts made with this larger error on the take-off resulted in another jump, the Loop jump. All participants had previously learned the Loop jump, as seen in the Pre-Study On-Ice Evaluation. The descriptive analysis revealed that the EG increasingly made fewer attempts with this type of error as the study progressed, with the exception of the RT. This decrease in the number of attempts was attributed to the treatment the EG received; as they became more familiar with the correct technique for the Inside Axel through VM, and practiced this technique through imagery, the more obvious errors decreased.

The CG also decreased in the number of attempts they made as Loops over time, but the trend was conservative. The CG consistently performed more attempts of this type of error than the EG, which was not unexpected, as the Inside Axel is similar to the Loop jump, except for the take-off direction (i.e., forward versus backward) and the amount of rotation (i.e., 1.5 revolutions versus 1 revolution). The participants, as noted above, could successfully complete the Loop jump. This prior knowledge may have interfered with the learning of the Inside Axel, and especially so, with no augmented feedback to correct for this mistake.

Interestingly, the number of attempts made with Loop jumps errors increased for both groups during the RT. This sudden increase may be explained by the participants' increased motivation to succeed on the last day of the study. For example, the participants may have realized it was the last day and, in wanting to land their attempts backwards, may have paid less regard to performing a correct take-off, and made more attempts as Loop jumps.

Summary of the Performance Data

The EG averaged both fewer attempts and fewer falls per day than the CG. The EG was expected to fall less than the CG, as it was thought that the EG would make more thoughtful and informed attempts due to their experimental treatment. Falls were not necessarily regarded as errors in learning the jump, as the other variables were, but rather as consequences of learning the jump. Errors made on the jump attempts were ranked from largest to smallest: Loops; correct take-off, but not successfully completed; and a small error on take-off, but successfully completed. Compared to the CG, the EG group committed fewer of the largest error, the Loop jump, and consistently made more attempts with correct take-offs, although these attempts were not successfully completed. The EG also increased in the number of attempts made with the smallest and most desirable error, those made with a small error on the take-off, but successfully completed. The attempts made with this small error were closest to successfully completing the jump.

Overall, the EG group had a higher percentage of 'good' errors and fewer 'bad' errors than the CG group. Further, the EG successfully completed more Inside Axels, had fewer falls, and made fewer attempts than the CG. Both groups were similar in skating ability, age, and in overall movement imagery ability and, although few statistically significant differences were found for any of the variables, it is concluded that the MI+VM treatment had a limited, but positive, effect on the EG's outcome.

General Discussion

The outcome of this study was limited, but showed a small positive effect for the treatment condition. After receiving the MI+VM treatment, the EG successfully landed more Inside Axels, while making fewer physical attempts and fewer falls, than the CG. These results indicate that MI+VM may provide a method for decreasing the potential for injury in developmental level skaters by helping to reduce the physical number of trials necessary to learn a new jump.

Unforeseen limitations emerged during the study, including missing participants, questionable effort from the participants, as well as timing and cooperation of the skating clubs, among others. Further, the study's methodology became problematic in regards to the timing of the treatments, the videos, and the imagery assessment. These issues and their potential implications are discussed in more detail below.

A methodological issue arose when the chronological data were moved to 'practice days'. In doing so, the potential for time to have a more significant effect on the results increased. For example, the time between treatments became less consistent between both participants and groups, and the present analysis must be read in consideration of this. It was discerned, however, that the most important factor to measure against was equal number of treatments, rather than equal time between treatments. The original schedule for the timing of the treatments was similar for both groups, but with participants missing days, the time between treatments did not remain equal for all participants in each group and between groups. This time inequality may have had an effect on not only the performance outcome, but on learning as well. Regardless of how the data were organized, however, the EG would have shown better results than the CG: fewer number of attempts, fewer falls, more completed Inside Axels, more completed jumps with only small errors on the take-off, fewer incorrect take-offs, and fewer Loop jumps.

The videos presented another methodological problem, in that they were soundless. The absence of sound was a technical problem created by background noise during taping of the models, as well as feedback noise in the transfer of original video footage to the editing program; all of the noise had to be eliminated in the final videos. The sound produced by the models' blades (e.g., gliding, pressing, lifting off, and landing) would have added an additional sensory item for the participants to be aware of while learning the Inside Axel. This addition of sound and auditory cues may have provided the opportunity for further depth in processing, and potentially greater retention of the jump.

Imagery assessment was another challenge with a lack of knowledge of what the EG participants were imaging. Participants indicated how often they used imagery during each PP session, but larger questions remain: Were the participants imaging correct representations of the jump? Did incorrect images affect the rate of acquisition? What was most important to image for this skill, the whole jump, or parts of the jump (e.g., take-off, landing, air position, etc.)? Did imaging lead to other outcomes besides increased depth of processing, such as increased confidence in the participant's perceived ability to complete the jump, or increased muscle memory? Were the CG also employing imagery, and if so, do the same questions apply? All of these questions remain to be answered in future research.

Summary

This study endeavored to examine the differences in the rate of acquisition of a complex motor skill by creating increased levels of cognitive processing via MI and VM strategies. In the past, complex motor skills, combined with MI and VM, had not been studied extensively, and rarely with children; imagery studies with children were also limited in number and scope; and LOP had only been extended into motor skill learning in a very limited way. This study aimed to provide more information in all of these areas.

The purpose of the RT was to establish that learning, and not simply changes in performance, had occurred. Although both groups had difficulty in learning the complete jump, all participants made relatively permanent changes in, or learned, at least one or more of the components of the Inside Axel (i.e., take-off, rotation, landing position).

Further, the group receiving the MI and VM treatment appeared to learn more, but with fewer physical trials.

No participants reached the autonomous stage of learning for the Inside Axel. It was concluded that this final stage of learning was reached by some of the participants, however, for the error most closely related to the Inside Axel (attempts that were successfully completed, but with a small error on the take-off), as illustrated in the high number of attempts with this error. Further, all participants, and those in the EG more so than the CG, could be characterized as reaching the intermediate stage of learning for the Inside Axel. The participants demonstrated the basic mechanics of the jump (i.e., all participants were correctly performing parts of the jump; the take-off, the air position, and the landing), and were beginning to refine their attempts.

The EG's advanced degree of learning was attributed to the MI and VM they participated in, and to the depth of the processing the MI and VM provided. Accurately assessing the precise depth of processing made by individuals is difficult, both in this study, and in general; the processing of information is a cognitive, and unseen, process. Depth of processing may be inferred from the retention of the individual, and manifested through performance, however. Craik and Lockhart (1972) suggested that increased attention to and processing time of a stimulus would create deeper levels of processing and lead to better retention. This study incorporated mental imagery and video modeling as methods to deepen the level of processing by increasing the amount of attention and processing time the EG participants gave to the Inside Axel. The overall, positive effect observed in the EG's results, as compared to those of the CG, revealed that more learning occurred by the EG, thereby indicating that the EG engaged in deeper processing than the CG.

The fluctuation in number of attempts made of each type of error, as well as in the number of completed Inside Axels, may be a result of performance itself; performance, by definition, is variable. As seen in the RT, the EG performed a greater number of attempts with 'good' errors and a fewer number of attempts with 'bad' errors. Through these changes in performance, it was inferred that learning had occurred. It can be assumed that more practice at the jump (through both mental and physical trials) would lead to an increased number of successful attempts; however, without coaching or another form of augmented feedback, the quality of these attempts cannot be assured. It was clear that the participants in both groups were learning, or at least on the correct path to learning, the Inside Axel, with the EG leading the way.

Implications, Recommendations and Future Directions

With the small sample size and, additionally, fewer data points attributed to missing participants, this study can not be generalized to other populations, but does add an imagery and video modeling field study, utilizing a complex motor skill, to both the youth sport and figure skating literature.

Despite the lack of statistically significant results in this study, as a coach, I was able to glean anecdotal ideas from the trends that emerged, as well as from the observations made during the study. As I viewed and coded the numerous videos of the PP sessions, it became apparent that after practicing the Inside Axel for approximately six minutes, the participants began to lose interest. This boredom was evident in the participants' behaviors, which included increased instances of talking to other participants, asking to use the washroom, etc., and was mentioned by some of the participants. In future research, boredom, from constantly repeating the same task, could be alleviated by either shortening the length of the PP sessions or by incorporating a second viewing of the video at the 5-minute mark. Including a second viewing of the models would not only circumvent boredom, but reinforce the skill and create another opportunity for deeper processing. I have addressed this issue of potential boredom when creating practice plans with my figure skating students of this age and ability range. Now, when practicing a specific skill, a specific number of repetitions or a specific amount of time, always of five minutes or less, is delineated.

Although the concepts of imagery and video modeling are not new, reflection of my experiences in the study and the recognition of the participants' positive reaction to imagery and video modeling, has led me to incorporate imagery and video modeling as learning tools during regular practices. The results of this study were limited, but I believe that by increasing the cognitive component of learning, increased depth in cognitive processing is created, leading to increased retention and then, possibly, to faster rates of acquisition. I have found that MI and VM, used as learning tools, both in this study, and outside of it, provide a positive supplement to the traditional methods of learning in figure skating.

In future studies, larger sample sizes are recommended to increase the power and reliability of the study, and to be able to generalize the findings to other populations of figure skaters. The inclusion of feedback, a longer timeline, and reliable methods for measuring both the content of the participants' imagery and their levels of motivation are also recommended, as well as establishing whether or not differences in age account for differences in depth of processing.

The inclusion of augmented feedback would provide a more complete view of the effectiveness of the VM+MI+PP treatment in measuring changes in the rate of acquisition. Feedback could be of various configurations: a coach administering verbal, augmented feedback, of positive or negative in nature, to the skaters regarding their attempts; video replay of the participant's real time attempts; etc.

The timeline for the study could be extended; seven days, as seen in this study, was too short for all participants to learn the skill and for consistency of the skill to develop in those who did. A more generous timeline would also decrease the impact of absent participants on the results. One suggestion would be to incorporate an open-ended timeline where participants would remain in the study until the jump was learned to consistency and then complete the RT.

Including effective and reliable methods of measuring the imagery content of the participants (e.g., what they are imaging) would be helpful in determining if what the participants are imaging is affecting the outcome.

Motivation (e.g., motivational climate, intrinsic motivation, etc.) of the participants was not measured in this study, but it appeared that motivation may have been a factor in the results received. Motivation can be inferred from behavior and, in regards to motivational climate, it was noted that differences appeared to exist when observing the coaches and other skaters who were training during the PP sessions, but who were not participating in the study. For example, the general energy, movement, and 'work' occurring on the CG's ice surface was tangibly greater, and created a more exciting and achievement-oriented atmosphere, than that of the EG's.

Further, it appeared that both the participants in the study, as well as the other skaters training on the ice during each of the PP sessions, may have had different levels of intrinsic motivation. For example, the CG participants appeared to be more motivated to fully participate and to accomplish the Inside Axel than the EG participants, as noted in differences in behaviors observed throughout the study's PP sessions, such as speed, the number of attempts made, and presumed work ethic. The CG's speed was consistently notably faster than the EG's, the CG consistently performed more attempts, and at greater speeds than the EG, and the CG appeared to use the 10 minute PP sessions more fully, with less idle time and less interaction with other participants (e.g., standing around in groups, and asking to use the washroom or take breaks).

In regards to the participants' interactions with me, the CG appeared to be more excited and interested in the study and their role in it. Their excitement and interest led me to suspect that the CG's outcome would be greater than, if not at least more similar to, the EG's. This was not the case, however, presumably due to the treatment condition that the CG was prescribed. It would have been interesting to see the effect on and outcome of the results, if the CG had been prescribed the MI+VM treatment.

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Appendix A

Mental Imagery Questionnaire (MIQ; Hall & Pongrac, 1983)

INSTRUCTIONS

This questionnaire concerns two ways of **mentally** performing movements, which are used by some people more than others, and are more applicable to some types of movements than others. The first is the formation of a mental (visual) image or picture of a movement in your mind. The second is attempting to feel what performing a movement is like without actually doing the movement. You are requested to do both of these mental tasks for a variety of movements in this questionnaire, and then rate how easy/difficult you found the tasks to be. The ratings that you give are **not** designed to assess the goodness or badness of the way you perform these mental tasks. They are attempts to discover the capacity individuals show for performing these tasks for different movements. There are no right or wrong ratings or some ratings that are better than others.

Each of the following statements describe a particular action or movement. Read each statement carefully and then actually perform the movement as described. Only perform the movement a **single** time. Return to the starting position for the movement just as if you were going to perform the action a second time. Then depending on which of the following you are asked to do, either 1) form as clear and vivid a mental image as possible of the movement just performed, or 2) attempt to positively feel yourself making the movement just performed without actually doing it.

After you have completed the mental task required, rate the ease/difficulty with which you were able to do the task. Take your rating from the following scale. Be as accurate as possible and take as long as you feel necessary to arrive at the proper rating for each movement. You may choose the same rating for any number of movements "imaged" or "felt" and it is not necessary to utilize the entire length of the scale.

RATING SCALES

Visual Imagery Scale

1	2	3	4	5	6	7
Very Easy to Picture	Easy to Picture	Somewhat Easy to Picture	Neutral (Not Easy nor Hard)	Somewhat Hard to Picture	Hard to Picture	Very Hard to Picture

Kinesthetic Imagery Scale

1	2	3	4	5	6	7
Very Easy to Feel	Easy to Feel	Somewhat Easy to Feel	Neutral (Not Easy nor Hard)	Somewhat Hard to Feel	Hard to Feel	Very Hard to Feel

Appendix A (Continued)

1. **STARTING POSITION:** Make a fist with your dominant hand (the hand you write with) and then place this hand on the same shoulder (e.g., right hand on right shoulder) such that your elbow is pointing directly in front of you.

ACTION: *Be sure to read the entire action before attempting it*
Extend your elbow so that your hand leaves your shoulder and is straight in front of you parallel to the floor. Keep your hand in a fist. Make this movement **slowly**.

MENTAL TASK: Assume the starting position (exactly as described above). Form as clear and vivid a mental image as possible of the movement just performed. **DO NOT PERFORM THE MOVEMENT.** Now rate the ease/difficulty with which you were able to do this mental task.

Rating

2. **STARTING POSITION:** Stand with your feet and legs together and your arms at your sides.

ACTION: Raise your right knee as high as possible so that you are standing on your left leg with your right leg flexed (bent) at the knee. Now lower your right leg so you are once again standing on two feet. Perform these actions **slowly**.

MENTAL TASK: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

3. **STARTING POSITION:** Stand with your feet slightly apart and your hands at your sides.

ACTION: Bend down low and then jump straight up in the air as high as possible with both arms extended above your head. Land with your feet apart and lower your arms to your sides.

MENTAL TASK: Assume the starting position. Form as clear and vivid a mental image as possible of the movement just performed. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

4. **STARTING POSITION:** Stand with your feet slightly apart and your arms at your sides.

ACTION: Jump upwards and rotate your entire body to the **left** such that you land in the same position in which you started. That is, rotate to the left in a complete (360°) circle.

MENTAL TASK: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

5. **STARTING POSITION:** Extend the arm of your nondominant hand straight out to your side so that it is parallel to the ground, palm down.

ACTION: Move your arm forward until it is directly in front of your body (still parallel to the ground). Keep your arm extended during the movement and make the movement **slowly**.

MENTAL TASK: Assume the starting position. Form as clear and vivid a mental image as possible of the movement just performed. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

Appendix A (Continued)

6. **STARTING POSITION:** Stand with your feet and legs together and your arms at your sides.

ACTION: Raise your left leg as high as possible keeping the leg extended (do not bend your left knee). At the same time keep your support (right) leg straight. Now lower you left leg so you are once again standing on two feet. Perform these actions **slowly**.

MENTAL TASK: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

7. **STARTING POSITION:** Stand with your feet slightly apart and your arms fully extended above your head.

ACTION: **Slowly** bend forward at the waist and try and touch your toes with your fingertips (or if possible, touch the floor with your fingertips or your hands). Now return to the starting position, standing erect with your arms extended above your head.

MENTAL TASK: Assume the starting position. Form as clear and vivid a mental image as possible of the movement just performed. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

8. **STARTING POSITION:** Make a fist with your nondominant hand. Extend your arm above your head keeping you hand in a fist. Keep you other arm at your side.

ACTION: Swing your extended arm straight down to your side as **rapidly** as possible. Keep your arm extended and your hand clenched.

MENTAL TASK: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

9. **STARTING POSITION:** Stand in front of the floor (exercise) mat with your feet together and your arms at your sides.

ACTION: Perform a front somersault (roll) on the mat and finish in a standing position.

MENTAL TASK: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

10. **STARTING POSITION:** Make a fist with your dominant hand (the hand you write with) and then place this hand on the same shoulder (e.g., right hand on right shoulder) such that your elbow is pointing directly in front of you.

ACTION: Extend your elbow so that your hand leaves your shoulder and is straight in front of you parellel to the floor. Keep your hand in a fist. Make this movement **slowly**.

MENTAL TASK: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

Appendix A (Continued)

11. **STARTING POSITION:** Stand with your feet and legs together and your arms at your sides.

ACTION: Raise your right knee as high as possible so that you are standing on your left leg with your right leg flexed (bent) at the knee. Now lower your right leg so you are once again standing on two feet. Perform these actions **slowly**.

MENTAL TASK: Assume the starting position. Form as clear and vivid a mental image as possible of the movement just performed. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

12. **STARTING POSITION:** Stand with your feet slightly apart and your hands at your sides.

ACTION: Bend down low and then jump straight up in the air as high as possible with both arms extended above your head. Land with your feet apart and lower your arms to your sides.

MENTAL TASK: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

13. **STARTING POSITION:** Stand with your feet slightly apart and your arms at your sides.

ACTION: Jump upwards and rotate your entire body to the **left** such that you land in the same position in which you started. That is, rotate to the left in a complete (360°) circle.

MENTAL TASK: Assume the starting position. Form as clear and vivid a mental image as possible of the movement just performed. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

14. **STARTING POSITION:** Extend the arm of your nondominant hand straight out to your side so that it is parallel to the ground, palm down.

ACTION: Move your arm forward until it is directly in front of your body (still parallel to the ground). Keep your arm extended during the movement and make the movement **slowly**.

MENTAL TASK: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

15. **STARTING POSITION:** Stand with your feet and legs together and your arms at your sides.

ACTION: Raise your left leg as high as possible keeping the leg extended (do not bend your left knee). At the same time keep your support (right) leg straight. Now lower your left leg so you are once again standing on two feet. Perform these actions **slowly**.

MENTAL TASK: Assume the starting position. Form as clear and vivid a mental image as possible of the movement just performed. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

Appendix A (Continued)

16. **STARTING POSITION:** Stand with your feet slightly apart and your arms fully extended above your head.

ACTION: **Slowly** bend forward at the waist and try and touch your toes with your fingertips (or if possible, touch the floor with your fingertips or your hands). Now return to the starting position, standing erect with your arms extended above your head.

MENTAL TASK: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

17. **STARTING POSITION:** Make a fist with your nondominant hand. Extend your arm above your head keeping you hand in a fist. Keep your other arm at your side.

ACTION: Swing your extended arm straight down to your side as **rapidly** as possible. Keep your arm extended and your hand clenched.

MENTAL TASK: Assume the starting position. Form as clear and vivid a mental image as possible of the movement just performed. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

18. **STARTING POSITION:** Stand in front of the floor (exercise) mat with your feet together and your arms at your sides.

ACTION: Perform a front somersault (roll) on the mat and finish in a standing position.

MENTAL TASK: Assume the starting position. Form as clear and vivid a mental image as possible of the movement just performed. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

Appendix B

Guided Mental Imagery

- Now that we've watched the video and know what is important in this jump, I'd like you to now try to imagine yourself doing the jump. First we will do it together, and then you will try it by yourself. I want you to listen really closely to me and repeat what I say silently to yourself and try to see yourself in your mind doing the jump just like the skaters in the video. I also want you to try to feel what it would feel like to do the jump while you are imagining yourself doing it.
- I'd like you to close your eyes quietly and take a deep long breath. Breathe in through your nose for 4 counts and feel your breath go all the way to the bottom so your tummy sticks out, and then let it out slowly through your mouth for 8 counts.
- Here we go. Repeat in your mind after me. I'm pushing hard on the crossovers for the set-up, keeping my arms up and back tall. I am coming down the ice and see a perfect spot to do the jump. I step on to the inside edge for the preparation and check my arms in an "L", free leg pointed in front, and balance. Once I feel balanced, I step on to my take-off foot on a small curve and push up to my toe pick and jump and my arms and my free leg squeeze in strong and controlled. I feel the rotation and am tall in the air like a pencil, skinny enough to fit in a toilet paper tube. My arms and legs start to open, but I am keeping my tummy and back strong and my head facing over my belly button. The landing feels really strong as my toe pick touches the ice and my free leg comes out and back and my arms open. My landing arms stay in a V and I hold the nice strong landing edge until I'm still and balanced. I did it!!

Appendix B (Continued)

- Now you are going to try to imagine and feel it in your minds by yourself. Start as soon as you are ready, and open your eyes when you are finished.

(Note - Participants may be seated or standing during this rehearsal.)

Appendix C

Definitions

Inside Axel Paulsen: The jump consists of a take off from a forward inside edge, rotates 1.5 revolutions in the normal direction of rotation, landing on the back outside edge of the normal landing foot (e.g., if the skater rotates in a counterclockwise direction the takeoff will be performed on the right forward inside edge, and the landing on the right back outside edge).

Attempt: Includes any motion that includes set-up and step onto the take-off edge. This will include any aborted set-ups, under rotated jumps, cheated take-offs, incorrect landings, as well as set-ups and jumps with falls.

Successfully Executed Attempt (Minimum Performance Criteria): The jump must rotate one and one half revolutions in the air with a clean take off and landing (i.e., point of take off must be from forward inside edge with the toe pick being the last contact with the ice; the landing must be completely backwards with no turning and/or under or over rotation). Skaters must approach the entry of the jump with a moving set up (forward or backward crossovers), and the landing must have both flow and control (i.e., skater is moving upon landing and the landing edge creates an arc; skater can maintain the landing without losing upper body control or three-turning the landing).

Appendix C (Continued)

Attempts Made with Correct Take-off, but not Completed: These attempts included a forward take-off from the toe picks but the amount of rotation in the air was less than 1.5 revolutions or (e.g. a three-jump) or ended with a fall.

Attempts with a Small Error on the Take-off, but Successfully Completed: This error is caused by a lack of quickness immediately preceding the moment of take-off. The skater is too slow in the take-off phase, turns up to one half of a rotation on the toe-picks before leaving the ice, and therefore, does not complete the full 1.5 revolutions in the air. However, the take-off is turned on the toe picks, and not on the blade, and therefore is considered a small error.

Attempts with Incorrect Take-off, but Successfully Completed (i.e., Loop Jump): In this error, the take-off is turned a half-turn on the blade (i.e., a 'three turn' in skating terminology), and the lift-off is from a backward edge, resulting in a different jump altogether, the Loop jump.

Appendix D

Parent / Participant Information Letter

Title of Project: The Effects of Mental Imagery, Video Modeling, and Physical Practice on the Rate of Acquisition of a New Figure Skating Skill

Principal Investigator:
Shauna Stewart
Faculty of Physical Education and Recreation
University of Alberta
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Research Supervisor:
Dr. Billy Strean
Faculty of Physical Education and Recreation
University of Alberta
Tel: (780) 492-3890

Dear Participant,

My name is Shauna Stewart. I am a Graduate student in the Faculty of Physical Education and Recreation at the University of Alberta. I am involved in a study about different ways of learning figure skating skills, and require participants for this study. Your child meets the criteria for the study and we would like her/him to take part in the study.

Information about the study (for example: time commitment and expectations of participants) follows. Please read this information. If you agree to your child's participation in the study, please fill out the accompanying consent form and return it to Shauna Stewart or your coach on or before February 05, 2004.

Who can be in the study?
Skaters (girls or boys) who are at the Preliminary freeskate level or compete at the Pre-preliminary level, are 7 to 12 years old, can land up to a lutz, but not yet land an axel, and are skating from January through March 2004.

How long is the study?
The study will last for 6 weeks, and will be spread out over these weeks. Participants will spend a total of 4 hours and 45 minutes involved with the study, plus 1 hour doing the mental imagery assessments, and possibly one 20 to 30 minute interview.

The maximum time commitment is 6 hours and 15 minutes, over 6 consecutive weeks. You will receive a schedule after the consent form is signed and returned.

What will skaters in the study be requested to do?
Skaters in the study will be asked to do the following things:

1) Be part of one of two groups. Each group will be asked to learn a new jump in different ways (e.g., mental imagery, watching videotapes, and practicing on ice).
2) The elements part of the Preliminary Freeskate test performed on-ice for a figure skating evaluator.
3) A short mental skills exercise and questionnaire off-ice before and after the study.
4) Eight 30-minute sessions (including both on- and off-ice sections) with the researcher, plus one extra 15-minute session (on-ice only) at the end of the study. The on-ice sessions will be videotaped. Both the off- and on-ice sessions will take place during regular skating times.
5) Some skaters may also be asked to speak to Shauna Stewart about what they learned or did in the study in an interview. The interviews (about 20-30 minutes long) will take place at the arena where your child skates and will be tape-recorded.

What are the benefits of being in the study?
Participants will help in increasing the understanding of mental skills and how they affect learning in skating. Skaters may learn how to get more out of practice sessions, will learn a new jump that not many people know how to do, and will get more experience performing for a judge.

Appendix D (Continued)

What are the risks of being in the study?
There is very little risk associated with being in the study. The chance of physical injury is the primary risk, but this risk is small. The jump the skaters will learn is well within their current level of skating ability. The primary investigator (Shauna) is a certified figure skating coach, and holds a valid emergency first aid and CPR certificate. In the event of an injury, first aid kits are located in the arena.

Given the instrumentation used to collect information for the study (i.e., interviews), another possible risk is the disclosure of personal or sensitive information. This may make some participants uncomfortable. If requested, referral to a counselor will be provided.

What if your child wants to quit the study?
Participants are free to leave the study at any time. If your child declines to continue or withdraws from the study all information specifically regarding your child's information will be removed from the study upon your request. However, even if your child leaves the study, we will still be videotaping the sessions, and your child's skating may be inadvertently be recorded. This information would not be used in the study in any way.

What will be done with the videos and interview information?
The videotapes of your child skating will be viewed by Shauna and two research assistants who know about skating, but are not involved with your child in any other way. For example, they are not skating evaluators/judges, your child's coach(es), etc. The interview tapes will be typed out and analyzed by Shauna. She will be the only one listening to the interview tapes.

Confidentiality
All participants' names and information will be kept confidential. Only the investigators will have access to your child's information and responses. Your coach(es) will be aware that your child is involved with the study, however, the information gathered during the study will be held in confidence from your coach(es), and will have no bearing on your child's status with his/her coach(es) or in the skating community.

To ensure anonymity, personal information will be coded and stored in a locked filing cabinet to which only the investigators have access. Normally, information is retained for a period of five years after publication, after which it will be destroyed.

Your child's responses to the questionnaires, interview questions, and ability to learn the new jump are not being evaluated in such a way that it would affect their status as a figure skater. All information gathered is solely for the purposes of this study: to find out more about how young skaters respond to different methods of learning.

Once the study is completed, you will receive a letter explaining the results of the study. This information will be forward to you through your skating club's office.

If your child would like to be in the study, please fill out the attached forms and return them to Shauna or your coach on or before February 05, 2004.

If you wish to speak to someone who is not involved with this study, please call Dr. Pierre Gervais, Assistant Dean (Graduate Studies), at 492-1039.

Sincerely,

Shauna Stewart, Principal Investigator
Billy Strean, Research Supervisor

Appendix E

Parental Consent / Informed Consent

Title of Project: The Effects of Mental Imagery, Video Modeling, and Physical Practice on the Rate of Acquisition of a New Figure Skating Skill

Principal Investigator:
Shauna M. Stewart
Faculty of Physical Education and Recreation
University of Alberta
Tel: (780) 492-3890

Research Supervisor:
Dr. Billy Strean
Faculty of Physical Education and Recreation
University of Alberta
Tel: (780) 492-3890

Please complete this form if you agree to participation in the study:

Do you understand that your child has been asked to be in a research study?	Yes	No
Have you read and received a copy of the Information Sheet?	Yes	No
Do you understand the benefits and risks involved in your child taking part in this research study?	Yes	No
Have you had an opportunity to ask questions and discuss this study?	Yes	No
Do you understand that your child is free to refuse to participate, or to withdraw from the study at any time, without consequence, and that your child's information will be withdrawn at your request?	Yes	No
Do you understand that even if your child leaves the study, your child may still inadvertently be videotaped, but that this information about your child will not be used in the study?	Yes	No
Has the issue of confidentiality been explained to you?	Yes	No
Do you understand who will have access to your information?	Yes	No

This study was explained to me and my child by: ______________________

I agree for my child to take part in this study.

______________________ ____________ ______________________
Signature of Parent/Guardian Date Witness

______________________ ______________________
Printed Name Printed Name

For the participant:
The study was explained to me and I fully understand my part in the study. I agree to be in the study. I believe that the person signing this form understands what is involved in the study and voluntarily agrees to allow their child to participate.

______________________ ____________
Signature of Participant Date

____
Printed Name

I believe that the parent signing this form understands what is involved in the study and voluntarily agrees to allow their child to participate. I believe that the child understands what is involved in the study and voluntarily agrees to participate.

______________________ ____________
Signature of Investigator or Designee Date

Appendix F

Non-Participant Information Letter

Title of Project: The Effects of Mental Imagery, Video Modeling, and Physical Practice on the Rate of Acquisition of a New Figure Skating Skill

Principal Investigator:
Shauna Stewart
Faculty of Physical Education and Recreation
University of Alberta
Tel: (780) 492-3890

Research Supervisor:
Dr. Billy Strean
Faculty of Physical Education and Recreation
University of Alberta
Tel: (780) 492-3890

Dear Parents:

I am doing a study with some of the figure skaters at [Name of Club]. The skaters participating in the on-ice sessions will be videotaped. These sessions may be the same sessions your child is also skating on, and your child may be videotaped by mistake. This letter is meant to both inform and ensure you that while your child may be videotaped during these sessions, no attempt will be made to use or analyze your child's skating in any way. Also at this time, I would like to ensure you that the study, and the skaters involved in it, will not negatively affect your child's ice time.

If you wish to speak with someone who is not involved with this study, please call Dr. Pierre Gervais, Acting Chair of the Faculty Ethics Committee, at 780-492-1039.

Sincerely,

Shauna Stewart
Principal Investigator

Appendix G

Independent Samples *t* test of Participants' Skating Ability (Pre-Study Evaluation)

Skill	*df*	*t*	*p*
Forward Stroking	15	0.79	0.45
Backward Stroking	15	1.04	0.32
Bunny Hop	15	-0.75	0.46
Waltz Jump	15	0.34	0.74
Salchow Jump	15	-0.58	0.57
Toe Loop Jump	15	3.32	0.01*
Flip Jump	15	1.87	0.08
Loop Jump	15	0.86	0.40
Lutz Jump	15	1.20	0.25
Axel Jump	15	-	-
Toe Loop/ Toe Loop Jump	15	0.66	0.52
Forward Upright Spin	15	-0.34	0.74
Backward Upright Spin	15	1.58	0.14
Sit Spin	15	0.82	0.43
Camel Spin	15	-0.14	0.89
Left Foot Spiral	15	0.05	0.96
Right Foot Spiral	15	1.18	0.26

* $p < .05$.

Appendix H

MIQ Results

Table A1

Independent Samples t test for Mean MIQ Scores Between Groups

MIQ	*df*	*t*	*p*
Pre-Study	14	.33	.15
Post-Study	14	-.18	.86

Table A2

Paired Samples t test for Mean Pre- and Post-Study MIQ Scores Within Groups

Group	*df*	*t*	*p*
EG	7	1.90	.10
CG	7	.98	.36

Table A3

Independent Samples t test for the Pre- and Post-Study MIQ Differences Between Groups (2-way Interaction)

df	*T*	*p*
14	-.78	.45

Appendix H (Continued)

Table A4

Independent Samples t test for Pre- and Post-Study Visual and Kinesthetic Imagery Comparison Between Groups

MIQ	Visual			Kinesthetic		
	df	*t*	*P*	*df*	*t*	*p*
Pre-Study	14	.03	.98	14	.64	.53
Post-Study	14	-1.08	.30	14	1.17	.26

Table A5

Paired Samples t test for Pre- and Post-Study Visual and Kinesthetic Imagery Scores

MIQ Component	Within Group					
	Experimental			Control		
	df	*t*	*p*	*df*	*t*	*p*
Visual	7	1.29	.24	7	-.53	.61
Kinesthetic	7	.94	.38	7	2.52	.04*

* $p < .05$.

From: Craig R Hall <chall@uwo.ca>
Date: April 19, 2006 12:59:10 PM MDT
To: sms9@ualberta.ca
Subject: Re: MIQ copyright permission

Dear Shauna

You have my permission to copy the MIQ in your final thesis paper.

Cheers,
Craig Hall
School of Kinesiology
University of Western Ontario