

Attentional Demands in the Execution Phase of Curling

Master's Thesis

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Abstract

Numerous studies have looked at cognitive processing, more specifically attention, and its important role in various dynamic and static movements. Research on attentional demands in sport is an expanding area with studies now being done on athletes revealing the role of cognitive factors in the execution of motor movements in sports. **Objective:** the purpose of this study was to determine the attentional demands of a delivery in curling using a classic probe technique with a verbal response time and by measuring numerous performance variables. **Subjects:** ten healthy skilled curling players and nine healthy novice curling players undertook an auditory probe reaction time concurrently with a delivery in curling. **Method:** Sixty shots were executed with ten shots for each of the three phases of the shot, in all 30 take outs and 30 draws were done by each participant. The first phase when the player comes out of the “hack”, the second phase of the throw was when the player slid across the “t-line”. The third phase is when the player arrives near the line of Hog and releases the stone. **Results:** results revealed that reaction times were longer at phase 1 of the delivery for all subjects. The attentional demands for the draw and take out were highest at the phase one of the delivery, furthermore, compared to the draw, a significant rise of RT was seen in phase 3 of the take out shot. Significant differences were also found between the two experimental groups, with the most notable ones being that expert had a better shot success and a slower delivery time than the novice group. **Conclusion:** These results will lead to a better understanding of the attentional demands of two key shots in the sport of Curling and help curling coaches and teachers, as well as the players of the sport to know more about the attentional demands of the execution movement of the sport. This study also opens a new and interesting perspective on the importance of attention while performing motor tasks that are more complex and demanding.

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General Introduction

Curling is a sport of great tradition, sportsmanship and companionship. It is also a game that attracts players of all ages and gender from countries all over the world. Invented in Scotland in the 16th century, curling was fully seen in Canada for the first time in the 1700's. It is mostly known as a game of strategy on ice and has enjoyed Olympic medal status since the Nagano Games in 1998. In terms of participation, curling is considered to be a newly adopted winter sport as only 5 million people in 36 countries curl, 80% of who are Canadians and only 1% who reside in the United States [Canadian Curling Association, 2009]. This next section of the introduction will be divided into the basic context of the curling delivery and curling generalities. We will be discussing the game of curling and the numerous components of the game that will be explored in order to make a logical hypothesis for this study.

Basic Context

The basic objective of curling is to deliver a 20 kg block of polished granite stone to a target at the end of a 46 m sheet of ice. The delivery of the stone is the primary motor skill found in curling. It is a perfectly coordinated movement that requires both precision and stability. It is performed by lifting the rock (or more commonly now sliding it back) before swinging it forward onto the ice, while pushing with the dominant leg towards the target. After pushing himself off the delivery hack, the curler will slide along the ice with his/her rock, while observing the stone's trajectory towards the target, weight and speed. Being in this secondary phase of the shot; the players will be in a position of extreme

knee flexion with the dominate leg and in a complete hip extension on its non dominant side. The player will then release the rock that will follow a curved path depending on its speed, the coefficient of friction between ice and stone and the direction handle given by the player. The shot is then considered successful when and if the rock comes to a stop in the location were the skip, the player who calls the shot, wants the rock in play (Canadian Curling Association, 2009).

Curling generalities

No experimental studies have been done on the game of curling and few studies have attempted to examine attention and the limited capacity to process information in sports. More precisely, looking at the different stages of a particular voluntary movement in sport is a fairly new concept seen in the domain of motor control and learning. Numerous studies, however have been done on attention, its relation to static and dynamic equilibrium, reaching and also on movement initiation in gait. In sports where the primary motor skill is executed at rapid speed, such as a serve in volleyball or a slapshot in hockey, the skill's motor phases are very brief and it is a challenge to measure their attentional load. In curling, the delivery of the stone is spread through two to tree seconds and each phase of the movement can be clearly separated, observed and measured.

There are three distinct phases to the delivery of a rock in curling. The first phase being at the beginning when the player is pushing out of the hack with his dominant leg, the second phase looks at the player sliding at the t-line toward his target on the ice and finally the third phase is when the player releases the rock at the hog line while turning

the handle on the rock right or left depending on the skip's request (Canadian Curling Association, 2011).

In this study we will look at the two basic shots in curling - a draw and a take-out. A draw is characterized as a strategic shot in which you usually see the rock stopping in front of or in the house. The draw is considered a more precise shot as the weight of the stone needs to be perfect for this shot to be considered successful, thus this shot is expected to require more attention to be completed effectively by the player. A take-out is characterized as a power shot which involves hitting and removing another rock from play. While this shot is considered a difficult shot which involves power and accurate aiming, this shot requires less processing from the player. This study will look at these two types of shot and thus look at the difference in attentional costs both shots have for the player.

Literature Review

Attention and attentional theories

Attention has been a topic of most important interest in the field of motor behavior researchers. Research on attention and the concept of limited processing capacity can be traced back to the early 19th century and a high interest in the topic remains today. Attention, being part of a very complex cognitive process affects nearly everything we do. The concept of attention has been defined by numerous researches as being the capacity of information processing in an individual, a cognitive process of selectively concentrating on one task or stimulus while ignoring or overlooking another. (Woollacott et al, 2002, Shumway-Cook, 2000a; Shumway-Cook, 2000b). Although there has been numerous theories and definitions for attention presented throughout the years, some key features are still important today. First, there is the notion that attention is limited, meaning an individual can only process one thought at a time, can only attend to one thing at a time and that at any given point there is generally only one focus for the processing of a certain task (Shmidt, 1988, Stark, 1997). This meaning that an individual does have a limited capacity of processing information and this capacity could be exceeded or affected if too much activity was attempted. The second statement that remains today is the notion of multiple pools or reservoirs of attention that can be given to different processing tasks as long as the allowance of these tasks does not exceed the amount of available resources (McLeod, 1977). Several different theoretical viewpoints immersed that try and explain the limitation of human performance. The following theories of attention attempt to explain the patterns of interference between two independent tasks, which kind of tasks do and do not interfere with each other and finally

under which conditions this interference could be expected to occur. In this next section we will look at some of the more predominant of these theories on attention.

The single-Channel Theory

The single channel theory looks at the human as the operator of a single and limited processing capacity channel. This point of view of having a single processing channel lets us to believe that an individual is limited to one task at a time and cannot process anything other than this one particular task. Thus the early stages of this theory look at the bottleneck theory that proposes every task must be performed in a serial manner and as a result other task must be held on “standby” until the previous task is completed (Broadbent, 1958 ; Deutsch and Deutsch, 1963). A great number of modified versions of this same theory were created given that it was clear to everyone that an individual can and does perform and respond properly to more than one stimulus at a time, contradicting that attention can only be given to one task at a time in a serial manner.

These versions of the single-channel theory look at a single-channel filter and the utilization of attention only at various stages of the processing of the task. Most of the everyday tasks we perform on a daily basis can be identified as a collection of processes involving various stages of processing. These stages include the stimulus identification (sensory storage and perceptual analysis), response selection and response programming. The filter theory is based on the fact that an attentional filter is located somewhere along the sequence of these stages and according to this theory; many stimuli can be processed by an individual simultaneously and do not require attention until they reach this filter. When this filter is reached however, only one stimulus can be processed and the other

ones get “filtered out” depending on which stimulus is required for the task at hand. Welford (1952) was the first to look at this filter concept; looking at each individual as a single-channel that can be occupied by only one stimulus at a time and that all the stages in the sequence required attention. For Welford, the attentional filter is located before the identification of the stimulus making the whole processing of the task serial. A later version of this theory was looked at by Broadbent (1958) and Deutsch and Deutsch (1963) who theorized that the attention filter is not located before but along the sequence of stages, more precisely the stage of the stimulus identification. Broadbent theory places the filter just after the sensory stage, the most “peripheral” stage of all. He therefore viewed perceptual analysis, response selection and response programming as requiring attention while stating that the sensory stage of the stimulus identification process did not require any attention. Deutsch and Deutsch, like Broadbent, theorized that the attentional filter is located in the stimulus identification stage but unlike Broadbent they see perceptual analysis as being automatic and not requiring any attention. They consequently place the filter just after the perceptual stage, more precisely just before entering the response selection, making response selection and response programming attentionally demanding. Finally, Keele’s (1973) theory places the filter a bit later in the sequence of stages than the earlier theories. For Keele, the stimulus identification stage and the response selection are two stages that are done without any attention for an individual and that attention is needed only at the start of the response programming stage.

Limited Capacity Theories

These limited capacity theories were proposed and developed after the single-channel theories were no longer valid as researchers now understood that it was possible to do more than one task simultaneously. These theories propose that one individual can process a secondary task at the same time as a primary task as long as the “limited processing space” of these combined tasks does not go beyond the person’s limited capacity. The first branch of this theory is the flexible-capacity theory which states that the available attention that can be given to a task or tasks can be compared to a sort of pool of attention. This pool can be used to process multiple tasks simultaneously as long as the attentional allocation does not exceed the amount of available resources (Kahneman, 1973). The theory states that the way the attention is distributed amongst these activities depends merely on the situation and characteristics of each activity performed.

The multiple-resource theory is the last branch of the limited capacity theories. It looks at numerous pools of attention and not only one as the previous theory stated. This theory proposes that we do not only have one central-information processing mechanism with a limited capacity but rather we have multiple mechanisms each with its limited processing capacity (Magill, 1993). Wickens (1980) proposed a very interesting concept regarding this theory. He stated that resources for the processing of information came from three separate areas of resources that he called “pools”. The first pool is the output and input modalities where we have the processing of vision, limb movement and speech. The second pool is the information processing which involves our perception, memory and response output. Finally in the last pool we have the processing of information which

includes the verbal and spatial codes. Looking at Wicken's theory, if the two tasks that are performed simultaneously are from two different pools of resource, they will not affect one another because they are not competing for the same attention. However, if these two tasks are from the same pool of resources they will be affecting each other's performance for they are competing for attention coming from the same pool (Wickens, 1980). From this proposed theory we could expect to see some competition for attention of the same pool of resources in this study. In the output and input modalities we can expect to see some competition between vision (aiming) and limb movement. Being that the verbal response falls in the same resource area as these two we can expect to see the verbal response to be affected by the last two as they will all be competing for the limited capacity of the same pool.

Dual-Task Procedures and the probe technique

A module that needs to be explored for this study is the dual task method also known as the secondary-task technique. Dual task paradigms were early tool used by researchers for evaluating the role of attention or processing costs in a simple primary movement (Ells, 1973; Posner and Keele, 1969; Frazier et al, 2006; Shumway et al, 2000a). This involved challenging attentional capacities; in particular the capacity of dividing the attention between two tasks (Brown et al, 1999; Manchester et al, 1989; Kerr et al, 1985). The degree to which the performance on one or both tasks declines indicates the amount of obstruction present between the processes controlling the two tasks (Abernethy et al, 2002; Brown et al, 1999; Woollacott et al, 2002; Shumway-Cook, 2000a; Shumway-Cook, 2000b).

Welch (1898) was the first to look at the secondary-task technique in relation to the type of secondary task performed by the individual. He made his participants count in multiples of two while looking at grip strength as a primary task. Welch concluded that depending on the type of secondary task being performed, the attention required to perform the task would differ from one task to another. Two types of secondary tasks emerged from his studies, individuals could either do a continuous secondary task or a discrete secondary task, both having a different effect on the primary task at hand. The continuous task requires the subjects to do a secondary task throughout the whole time they are doing the primary task. He concluded that as the counting became more challenging, the secondary task became affected also (Welch, 1898). Other studies looking at continuous secondary tasks added a motor skill as their secondary task in addition to a motor skill for the primary task. These studies found that a continuous motor secondary task was even more challenging for the participants (Abernethy, 1988). The other type of secondary task used in attention research is the discrete task. It is this type of task that we will be using in this study. This method used to measure attentional demands on a primary task is called the probe technique, the probe is a discrete secondary task for it is presented only at various times or specific places while the subject is doing his primary task. This particular type of secondary task is usually completed manually or verbally by the subject. The probes are made with an effector that is independent to the primary task and usually the individuals don't know when the probe will be heard or seen. For this study the probe utilised is an auditory "BEEP" and the individuals' reaction time (RT) will be measured as they respond verbally to this probe.

Numerous studies have been done regarding the probe secondary task. Posner and Kelle (1969) , looked at the difference in attentional demands when the primary task was simple versus to when it was more complex. The concluded that when a primary task is fairly simple, the attention needed for the processing of this task is low and as a result more attention is allocated for the processing of the probe stimulus. Consequently, if the primary task is very demanding, as we will see in this study with the curling delivery, little of the spare capacity remains for the players to react to the probe task and thus the processing of this secondary task will be slower (Posner and Kelle, 1969). Another study by Posner and Keele (1969) using a discreet probe stimulus as a secondary task revealed interesting results. Individuals participating in the study were asked to do a wrist twist of a handle through a movement range of 150 degrees and move a pointer towards a target. Various probe stimuli were presented at different locations, at 15, 45, 75, 105 and 150 degrees. The concluding results of their study showed a graph with a U shape line indicating a higher response time at the beginning of the movement and again at the end of the movement. The reaction time was at its fastest in the middle sections of the movement indicating that these positions were less attentionally demanding than the others.

Another study by Ells (1973) looked at the attentional demands of a primary task at three different phases of the primary task movement. Ells had three probes locations: an initiation probe at the beginning of the movement, an execution probe while the movement is being done and again at the termination probe situated at the end of the movement. The subjects for this study were asked to move a handle with one hand towards a target and respond to the reaction time stimulus with the other hand. Results

from this experiment showed that not all phases of a primary discrete movement required the same amount of attention. Interesting enough, Eells concluded that attention demands were highest at the initiation phase of the movement and then again at the termination phase depending on the accuracy of the movement completion. As for the middle phase of the movement, the attentional demands seemed to be decreasing. Eells also stated that the relative degree of attention necessary for the execution of a movement is thoroughly related to the accuracy, the position and complexity of the movement (Eells, 1973; Magill, 1993).

There have been several other studies in the past that have looked at the temporal distribution of attention throughout a movement using a probe reaction time. The movement tasks measured in these studies, while being slightly different from a delivery in curling, can help predict the outcome of the present study. A study by Wilke (1976) looked at the attentional demands throughout the execution of a throw in darts. He had subjects seated at a distance of 8ft from the target and the probes were presented either at a) before the movement began, b) immediately after the recoil of the arm began, c) at maximum recoil, d) after the forward movement began and e) immediately after the release of the dart. Subjects were asked to respond verbally when they heard the auditory stimuli presented to them. The results from Wilke's study indicate that a slow reaction time in segment B of the movement compared to the faster reaction time seen in the later segments indicates that processing capacity was occupied immediately after movement onset to a greater extent compared to later in the movement.

Another interesting study this time on hurdlers showed similar results. This study by Castiello et al (1988) had 8 expert sprinters doing a 110m-hurdle while responding

verbally to an auditory stimulus presented five times throughout the race. The probes were presented a) at the start, b) when the athlete was about to jump over the first hurdle, c) at the 50m mark of the race, d) when the runner was about to jump over the last hurdle and e) at the last thrust of the race. They found that the reaction time was significantly slower at the start (segment a) and again just before the end of the movement (segment e). They concluded that a slow reaction time in segment A was attributed to the fact that the attentional resources at this phase of the movement are entirely devoted to the preparation of the motor command. At the last stage of the race the runners had a fast reaction time once again; the researchers concluded that the athlete was allocating most of his attention to performing the last thrust and allocating the position of the finish line. As for the intermediate stages of the movement (segments b through d) there was a clear decrease of attention demands as the reaction times for those segments were significantly faster (Castiello et al, 1988). From studies such as these we can expect the attentional demands in this study to be higher at the initial phase of the movement (phase 1) and again at the termination phase (phase 3) while a lower reaction time in phase 2 is expected as less attention will be needed for the processing of that stage of the delivery.

Equilibrium, posture and gait

Numerous studies have shown that attention is needed for establishing and maintaining good equilibrium and posture. Depending on the type of movement performed it can take a lot of the available processing capacity of an individual (Brown et al, 1999; Woollacott et al, 2002; Manchester et al, 1989, Lajoie et al, 1993). Equilibrium

and posture are crucial mechanisms needed in curling for the execution of the rock delivery and the realization of a successful shot for the reason that the essential constituent of the delivery for a shot in curling requires the player to push out of the hack and have its whole body balancing over the sliding foot, all on an icy surface (Canadian Curling Association, 2009). Having good balance is a key component in curling because it allows the body to slide more upright therefore assuring that the slide becomes and stays straight. Throughout the primary stages of the delivery, balance for the player simply means not favoring either side (rock side or broom side) when pushing out of the foot hack. A straight slide in curling is vital given that it will create a straight line of delivery thus permitting the player to maintain a desirable speed and aim more accurately at his target and therefore producing a more precise shot (Canadian Curling Association, 2009).

It has been said that postural control only requires an involuntary response and is independent from any cognitive processing (Manchester et al, 2001). Nevertheless, numerous studies since have since questioned that hypothesis and thus concluded that cognitive processing, more specifically attention, plays an important role in equilibrium and posture control (Manchester, 2001; Brauer et al, 2001, Brown, 1999). From these studies, it can be said that postural control is attentionally demanding and not done automatically and also that the attention demands increase with the complexity of the postural task being performed (Hyeong-Dong, 2009; Manchester et al, 1989). The attentional demands of regulating posture and equilibrium depend on the degree of difficulty of the postural task being accomplished, the performance of the posture

regulating systems, such as proprioception, sensory integration and vestibular information. It also depends on the presence or absence of other tasks being performed simultaneously requiring processing resources (Manchester et al, 2001; Brauer et al, 2001). This will be the case in this study as the curling delivery is a complex and challenging task. Attention and equilibrium have been researched thoroughly by a variety of researchers who tried to confirm that balance control requirements are increased when going from a static to a more dynamic movement (Hyeong-Dong et al, 2009; Itshak et al, 2004; Manchester et al, 1989, Lajoie et al, 1993). From results such as these we can expect to see high attentional demands in the curling delivery as it is not only a dynamic movement but a complex movement as well.

Gait an Gait initiation

In order to explore previous studies that have looked at the same key components found in this study, we had to associate the movement of a curling delivery to another locomotive movement. Gait seemed to be the most relevant given that gait initiating and gait itself can be compared to the curling take off and the delivery for numerous reasons. Gait initiation is the moment of transition between standing and the body becoming unbalanced in such a way as to permit a subject to pick one foot off the ground in order to take the first step. Gait is defined as the walking pattern of an individual looking at limb speed, limb coordination and movement.

Equilibrium plays a crucial role in the execution phase of gait and also in curling. When constant regulation of gait is needed (changes in direction or velocity) a supraspinal contribution is necessary in order to execute movements adapted to the

environment (Brown et al, 1999; Woollacott et al, 2002; Manchester et al, 1989). This kind of supraspinal contribution and sensory integration requires attention and thus there is some attentional cost to the regulation of equilibrium and to maintain it in an unpredictable environment (Brown et al, 1999; Hyeong-Dong et al, 2009; Manchester et al, 1989). In addition, effective navigation through dynamic movements such as gait requires adequate integration of peripheral information and communication between spinal and supraspinal structures (Haufler et al, 2000). We can, as a result, expect the same integration of peripheral information to come into play during a delivery on curling. Peripheral information from the somatosensory systems such as proprioception, vision and the vestibular system that plays different roles in gait regulation that can also be applicable to the equilibrium of the delivery in curling. For instance, visual inputs are important to determine gait speed (McFadyen, 2007; Haufler et al, 2000) there is also evidence of vestibular information during the execution of gait (Bent, 2004) whereas proprioceptive inputs have been seen to be more important during the primary and terminal phase of the movement (Haufler et al, 2000). These elements are critical for the development of the body's interpretation of relative movement through a variety of sensory inputs.

Gait initiation will also be an important component to explore since it can be compared to the initiation of the delivery in curling. This study will be not only looking at the attentional demands at the initial phase of the shot which is where the take off for the delivery is done but we will also be comparing two different types of shots and the initiation of the movement plays a crucial role in the execution of those highly different types of shots. As in the initiation of gait, the beginning of the shot is physically

demanding, the players starts with the use of muscle power and coordination from the lower half of the body. The start of the delivery stresses the large muscles of the legs as the key power generators for the shot. The delivery skills of this phase, when done properly, are demanding for the player and need to be fluid in order to be successful (Canadian Curling Association 2009; Shibasaki, 2004). Gait initiation is a complex motor skill that requires the integration of mechanisms of locomotion with those of balance, motor control and musculoskeletal functions (Brauer et al, 2001; Shumway-Cook et al, 2000a). Attention demands in gait initiation have been thoroughly studied using sensorymotor tasks (auditory, visual reaction time) and or cognitivs tasks such as figuring out math equations (Brown et al, 1999; Itshak et al, 2004; Siu et al, 2009). These studies have concluded that gait initiation is attentionally demanding and not done automatically (Hyeong-Dong et al, 2009; Manchester et al 1989; Brauer et al, 2001; Brown et al, 1999; Siu et al, 2007). From these results on gait initiation we can anticipate that for the curling delivery the initial take off (phase 1) will be the most demanding attentionally Studies have shown that a gait cycle has different dynamic postural demand according to its different phases, single support and double support. Within a gait cycle the attentional demands differed from when the participants were in single support meaning they only had one foot in contact with the ground to when they were in double support when both feet are in contact with the ground. These studies have shown that attentional demands were greater in the single support phase as the equilibrium was challenged a lot more than in the double support phase that required less processing. (Brown et al, 1999; Woollacott et al, 2002; Manchester et al, 1989, Lajoie et al, 1993).

Results from studies such as these could be used in a curling setting meaning that there could be different dynamic postural demands in the different phases of the shot.

Still looking at attention demands and gait, studies done on the attentional demands while walking towards a target have also shown some interesting results. Bardy and Laurent (1991) did a study that asked participants to respond manually to a sequence of auditory signals while walking towards a target. The increase in RT during the target approach phase of gait indicated a higher attentional load in comparison to the intermediate displacement phase. These results reveal that the final control stage in locomotor positioning is a stage that requires attention. Thus the authors concluded that this attentional load does in fact correspond to the resources used by subjects to begin and control their deceleration and process the visual-manual positioning of their walk towards the target (Bardy and al, 1991). From this study we can expect to see an increase in attentional demands in the termination phase of the delivery in curling as the participants will not only be approaching their target but they will begin to control their deceleration on the ice.

Sensory intergration and aiming

Sensory integration is a neurological process that continually organizes sensation from one's own body and from the environment making it possible to use the body effectively in his surroundings (Varraine et al, 2002; Monaco et al, 2006). It is also how the brain processes various sensory inputs coming from its own body and/or the surrounding environment and transforms them into usable functional outputs (Lavie et al, 1995; Woollacott et al, 1986; Manchester et al, 1989). Recent studies have indicated that the

complex regulation of sensory and motor information that maintains postures and assures equilibrium is controlled at the level of the cortex making the task not automatic but controlled (Brauer et al, 2001). As opposed to previous hypothesis, this type of cortical representation and regulation of the body's posture does require attention (Brauer et al, 2001). The perceptual load theory from Lavie N, (1995) recognized some interesting information concerning sensory integration; it confirmed that the extent of the audiovisual integration would depend on available attentional resources (Lavie et al, 1995). Lavie's perceptual load theory (Lavie, 1995) suggests that individuals can efficiently filter out task-irrelevant distracters from their environments when performing certain movements. Also, the perceptual load selectivity chooses what to process by way of limiting or freeing the processing capacity. This theory opens a new and interesting perspective in regards to the curling delivery. Depending on the attentional demands of the delivery, if it takes too much of the available attentional capacity of the player it may influence the way they react to the probe. The players may filter out the probe as it is task irrelevant to the curling delivery and thus the players may not even hear the probe if the attentional demands for the delivery are too high.

Several kinematic studies on target aiming have looked at actions toward external targets based on visual information (Monaco et al, 2006; Berkinblit et al, 1995). Complex movements often occur either while we are moving or when objects in the world move around us, thus constantly changing the spatial relationship between our body and the space in which our targets are. Target aiming also plays a central role in the game of curling, the precision and success of every shot depends on it. To begin, we have the

sensory input of the visual system that is crucial for aiming towards the target during the delivery. After the player leaves the hack, with his broom and the stone, he glides down the ice, aiming squarely for the skip's broom. When the player is sliding down the ice towards a target the brain processes various sensory inputs coming from its own body, such as vision, vestibular and proprioceptive inputs. These functional inputs are crucial elements that will lead to a successful shot.

Vision and proprioception contribute to the accuracy of target anticipation and aiming. Reaching toward a visual target involves the transformation of visual information into appropriate motor commands (Monaco et al, 2006; Adamovich et al, 2001). This transformation does indeed have an attentional cost and we can therefore anticipate a longer reaction time for the higher attentional demands of target aiming. Some studies have looked at this transformation of external information when it came to target and concluded that if a target is always presented in the same location every time, the transformation and identification can happen more quickly and consequently require less attention (McDowd et al, 2007). In curling, the target continuously changes from one shot to the other, in consequence this transformation and identification can take a long time to happen and as a result the attentional demands for that movement can stay high for a long time. The target continuously changes in the sport of curling for the reason that every shot is different and also the ice plays a big factor in where the skip will put his broom. If the ice is fast the broom will be closer to the location where the rock will come to a stop and the opposite happens when the ice is slow. For this reason, the target will keep changing as the ice surface changes. This will cause for the attentional demands to

keep being high throughout for a long period of time as the players' can never get used to a certain target location.

There has also been studies that have looked at the relation between target aiming and skill level. They concluded that because the attentional demands are relatively higher for novice players, greater effort is required for them to process sensory-perceptual information when aiming (Kerick et al, 2000; Haufler et al, 2000; Fitts, 1967). Previous data also suggests that skilled participants are more task-efficient, have a better organization and control of the task at hand. They also require less cortical activation to produce a higher quality performance when aiming than the novice players (Kerick et al, 2000; Haufler et al, 2000; Fitts, 1967).

Novice and skilled players

A direct approach used in sports performance is to examine the difference between skill levels, comparing beginners and experts in a specific task. Previous studies have identified three cognitive phases of psychomotor skill acquisition: the beginning, intermediate, and the advanced performers. This advanced and final stage is associated with non effortful analysis, concentration, and automaticity of the task at hand (Fitts, 1967; Allard, 1993; Landers et al, 1994). Others have then looked at the idea that the automation in the movements of the skilled players appears to decrease attentional involvement and effort compared to the novice players (Allard et al, 1993, Landers et al, 1994). Thus, as the player's skills become well learned with practice, they can be performed automatically. Doing a skill "automatically" thus implies that this particular skill can be done without conscious attention demands (Magill, 1993; Schneider and

Shiffrin 1977). Schneider and Shiffrin (1977) were amongst the first to look at different forms of human information processing and the difference between performing a new skill and doing a well learned skill. It was understood that two kinds of information procession operations existed: automatic detection and controlled search. Schneider and Shiffrin (1977) determined that skilled individuals would have more of a parallel and automatic processing of information while a controlled processing which is more slow and serial was seen in more novice individuals. Studies done on attentional demands in a hockey slap shot (Leavitt, 1979) or on putting the ball in golf (Beilock and Carr, 2001) on novice versus skilled individuals looked at the impact of a secondary task on new skill acquisition and high performance. These studies characterized expert performers as: performing better than novice performers, showing progressively greater skill as a function of practice, solving problems with greater cognitive ease within their specific skill domain and exhibiting relative automaticity of action. Hence, with practice a skill becomes relatively well leaned and attention may not be needed for step by step control of the movement which leaves room for the processing of an unrelated stimuli (Holyoak et al, 1991; Allard 1993, Schneider and Shiffrin, 1977; Fitts and Posner, 1967; Beilock and Carr, 2002; Leavitt 1979). As a result, the information processing style of the expert performer appears to be more effective, well-organized and capable of altering information to focus on decision and strategy processes (Baumeister, 2008). In contrast to the skilled performers, the novice player's state is characterized by stimulus identification and controlled processing which is supported mostly by a set of unpracticed and disintegrated control structures that attend to the task at hand in a step-by-step manner. This step-by-step fashion helps the novice performers to find the relevant internal and

external information for the motor task at hand (Wrisberg, 2001; Fitts and Posner, 1967; Beilock and Carr, 2002; Holyoak et al, 1991; Allard 1993, Schneider and Shiffrin, 1977). From these theoretical frameworks we can predict that in this study we will see a difference in attentional demands between the skilled and novice curling players. For all player's, at the initial stages of the delivery attention will be a necessary ingredient and less attention will be allocated to the outside stimuli. The skilled curlers will have more available attention to devote to a secondary task without interfering with the curling task at hand in the initial phase, which we do not expect to see in our novice players.

Another recent concept intensively researched in novice and skilled performance is on the attentional focus of the players associated with skill level. From these studies two types of attention emerged: internal and external attentional focus. Internal attention focus is directed towards how a movement is being executed. This involves various instructions to the subject such as the force required to do the task or concentration on the step-by-step technique of the skill. As opposed to having an internal focus, the external focus deals with focusing on an object in the environment, often a target, or the outcome of the action at hand. Studies looking at attentional focus throughout various skill levels have shown that skilled individuals perform better using an external focus of attention while the novice individuals performed better while focusing their attention on the internal components of the action (Beilock and Carr, 2002; Gray, 1991). The findings of Beilock et al. (2002), together with other theoretical studies, suggest that the negative effects of internal focus of attention might be greater for high-skill athletes than for low-skill athletes. Also, because the control mode for novice individuals would probably be far less 'automated' than that of high-skill athletes, it is expected that the performance of

low-skill individuals under an internal focus of attention would be less damaging or, perhaps, even better than with an external focus of attention (Perkins-Ceccato, 2003; Beilock et al, 2002). Bernstein (1996) suggested that an external focus of attention might be more favorable for skilled athletes than novice athletes because their levels of automaticity are different. Bernstein also argued that motor skills and their subcomponents are more automatic in expert athletes than in non-experts. Thus, an internal focus of attention would essentially overturn the skilled athlete to a mode of control associated with less skill consequently disrupting their current mode of control. More specifically, focusing on the external factors, such as the outcome of the action or a target, promotes the utilization of the automatic (unconscious) processes, while an internal focus on one's own movements results in a more conscious form of control that disrupts automatic control processes and holds more of a processing cost for the athlete. Support for these theories comes from studies showing reduced attentional demands when these skilled performers adopt an external as opposed to an internal focus (Wulf et al, 2001; Perkins-Ceccato, 2003). From these studies we can thus expect to see a slower reaction time for the novice players as they will have more of an internal focus of attention, concentration on their leg force, balance and sliding form which will demand more attention in the execution of the curling delivery. Contrary to the novice player's we can expect a faster reaction time from the skilled players as they will direct their attention towards external cues like the target at the end of the ice and the outcome of the shot which are said to be more automatic and less attentionally demanding.

The purpose of this study is to examine the attentional demands of each phase of a curling shot with the use of a secondary task. In this study we will be using an auditory probe to measure the attentional demands of three distinct phases of the rock delivery. We will also compare the attentional demands of two typical curling shot; the take out and the draw. Also, we will compare the attentional demands between a group of skilled curlers and novice curlers.

Performance variables will also be measured during the curling delivery. We will be measuring the player's delivery speed, and the shot success of every shot. Finally, we will be measuring the distance by which the target was missed on unsuccessful draw shots.

General Hypothesis

The phase of departure (phase1) will be the one that requires the most attention in both groups for the take out and the draw because several factors come into play during this stage of the shot. We hypothesized the regulators of balance; the muscular strength for the push as well as the cognitive factors to plan the sequence of movement will be taking a lot of the players' processing capacity at this stage in the shot. This will be marked by a slower response time. Attentional demands will be highest at phase 1 for both groups. We also believe that the biggest difference between both groups of players will be in phases 2 and 3 where the novice players shall have a longer reaction time than the skilled. It is believed the skilled players will have a shorter reaction time in phase two and three because the execution movement becomes more automatic with time and practice. As a result, we believe that for skilled players the shot is entirely programmed

as the player is leaving the hack (phase 1). Novice players will show a higher reaction time in phases 2 and 3 because they will be modifying their shot even after leaving the hack (phase 1). Based on the multiple resource theory of attention, longer reaction time would indicate higher cognitive demands from the ongoing phase of throw. Thus a faster reaction time would indicate lower cognitive demands from the ongoing phase of throw. It is also believed that the draw shot will demand more attention due to the fact that the shot is proven to be a precision shot where aiming, rock weight and position is highly important.

We believe that skilled players will show better shot success percentages for both types of shot as they have more experience and practice. We also believe that the skilled group will have a lower distance from center average on missed draw shot than the novice group as they have more experience and practice. Finally, our last hypothesis concerning delivery speed is that the skilled players will have a faster delivery speed as they are more stable on the ice and are comfortable with the delivery and the push off.

Significance of study

Many studies in the field of motor control have looked at the attentional demands of various balance and locomotion tasks such as walking, sitting and standing. In this study we will study attentional demands related to curling. We will observe which phase of the shot is more attentionally demanding at the expert and novice levels. We will also look at the two principal shots in curling, the draw and the take out, and therefore examine the attentional demands for these different shots. In the future, curling coaches and teachers, as well as the players of the sport shall know in advance the phase that is

the most attentionally demanding for them and thus can spend more time working on that part of the execution movement to perfect it. This study will also open an interesting and new approach to the domain of motor control and learning on the importance of cognitive functions while doing more demanding and complex motor movements.

CHAPTER II

Article to be submitted

Attentional Demands in the Execution Phase of Curling

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Abstract

Numerous studies have looked at cognitive processing, more specifically attention, and its important role in various dynamic and static movements. Research on attentional demands in sport is an expanding area with studies now being done on athletes revealing the role of cognitive factors in the execution of motor movements in sports. **Objective:** the purpose of this study was to determine the attentional demands of a delivery in curling using a classic probe technique with a verbal response time and by measuring numerous performance variables. **Subjects:** ten healthy skilled curling players and nine healthy novice curling players undertook an auditory probe reaction time concurrently with a delivery in curling. **Method:** Sixty shots were executed with ten shots for each of the three phases of the shot, in all 30 take outs and 30 draws were done by each participant. The first phase when the player comes out of the “hack”, the second phase of the throw was when the player slid across the “t-line”. The third phase is when the player arrives near the line of Hog and releases the stone. **Results:** results revealed that reaction times were longer at phase 1 of the delivery for all subjects. The attentional demands for the draw and take out were highest at the phase one of the delivery, furthermore, compared to the draw, a significant rise of RT was seen in phase 3 of the take out shot. Significant differences were also found between the two experimental groups, with the most notable ones being that expert had a better shot success and a slower delivery time than the novice group. **Conclusion:** These results will lead to a better understanding of the attentional demands of two key shots in the sport of Curling and help curling coaches and teachers, as well as the players of the sport to know more about the attentional demands of the execution movement of the sport. This study also opens a new and interesting perspective on the importance of attention while performing motor tasks that are more complex and demanding.

Keywords: Attention, Curling, Novice, Skilled, Curling performance

Research of attentional demands on athletes is an expanding area in the domain of motor control and learning with studies revealing the role of cognitive factors in the execution of motor movements in sports. While studies have attempted to examine attention at different stages of a particular voluntary movement and the limited capacity to process information in sports, no studies have attempted to look at these components in the sport of Curling.

Dual task paradigms were an early tool used by researchers for evaluating the relative attentional demands associated with different postural tasks and simple primary movement (Ells, 1973; Posner and Keele, 1969; Fraizer et al, 2008; Woollacott et al, 2000). This involved challenging attentional capacities; in particular the capacity of dividing the attention between two tasks (Brown et al, 1999; Manchester et al, 1989; Kerr et al, 1985). Using this general approach, several authors have demonstrated that attention is needed for establishing and maintaining good equilibrium and posture and as postural demands increase, the demands for attentional resources increase as well (Brown et al, 1999; Woollacott et al, 2002; Manchester et al, 1989, Lajoie et al, 1993). Attention demands in gait and gait initiation have been thoroughly studied using sensorymotor tasks (auditory, visual reaction time) and or cognitiv tasks such as figuring out math equations (Brown et al, 1999; Itshak et al, 2004; Siu et al, 2009). Bardy and Laurent (1991) demonstrated that walking requires more cognitive processing than simple sitting or standing. They also demonstrated that walking towards a small target required more attention than walking towards a larger target. These studies have concluded that gait initiation is attentionally demanding and not done automatically, when the modifications of the speed, changes in direction or precision is required supraspinal inputs are

necessary to perform movements adapted to the environmental context (Hyeong-Dong et al, 2009; Manchester et al 1989; Brauer et al, 2001; Brown et al, 1999; Siu et al, 2007).

Dual task paradigms have also been used to observe the temporal distribution of attention throughout a primary movement. For example, Wilke (1976) looked at the attentional demands in a simple throw in darts. He reported that a slow reaction time in the early segment of the movement compared to the faster reaction time seen in the later segments indicates that processing capacity was occupied immediately after movement onset to a greater extent compared to later in the movement. A study by Posner and Keele (1969) looking at the cognitive demands throughout a simple wrist movement revealed that there was a slower reaction time at the beginning of the movement and again at the end while reaction time was at its fastest in the middle sections of the movement indicating that these positions were less attentionally demanding than the others. Another study by Ells (1973) looked at the attentional demands of a primary task at three different phases of the movement. The subjects for this study were asked to move a handle with one hand towards a target and respond to the reaction time stimulus with the other hand. Results from this experiment showed that not all phases of a primary discrete movement required the same amount of attention and that cognitive demands were highest at the initiation phase of the movement and then again at the termination phase depending on the accuracy of the movement completion. As for the middle phase of the movement the attention demands seemed to be decreasing. Ells (1973) also stated that the relative degree of attention necessary for the execution of a movement is thoroughly related to the accuracy, the position and complexity of the movement. Castiello et al (1988) showed similar results, they concluded that that reaction time was significantly slower at the start

and again just before the end of a running movement. Thus they demonstrated that a slow reaction time in the early segment was attributed to the fact that the attentional resources at this phase of the movement are entirely devoted to the preparation of the motor command. The results from these studies lead us to believe that the curling delivery does require some attention and that not all phases will have the same cognitive demands.

Another direct approach used in sports performance is to examine the difference between skill levels, comparing beginners and experts in a specific task. Studies have looked at the idea that as the player's skills become well learned with practice, they can be performed automatically, this automation in the movements of the skilled players appears to decrease cognitive involvement and effort compared to the novice players (Allard et al, 1993, Landers et al, 1994). Studies done on attentional demands in a hockey slap shot (Leavitt, 1979) or on putting in golf (Beilock and Carr, 2002) on novice versus skilled individuals characterized expert performers as: performing better than novice performers, showing progressively greater skill as a function of practice, solving problems with greater cognitive ease within their specific skill domain and exhibiting relative automaticity of action. Also, studies looking at attentional focus throughout various skill levels have shown that skilled individuals performed better because they were using an external focus of attention while the novice individuals performed while focusing their attention on the internal components of the action (Beilock and Carr, 2002; Gray, 1991). Support for these theories comes from studies showing reduced attentional demands in skilled performers as they adopt an external focus of attention as opposed to an internal focus seen in the novice players (Wulf et al, 2010; Wulf et al, 2001).

The aim of this experiments was to examine the attentional demands of each phase of a curling shot, compare the cognitive demands of two types of shot and compare the attentional demands between the skilled and novice players. We will also look at performance variables such as delivery speed, shot success percentages and measured distance in missed draw shots. It is believed that attentional demands will be highest at phase 1 for both groups because the regulators of balance; the muscular strength for the push as well as the cognitive factors to plan the sequence of movement will be taking a lot of the players' processing capacity at this stage in the shot. It is also believed that the biggest difference between both groups of players will be in phases 2 and 3 where the novice players shall have a longer reaction time than the skilled. It is believed the skilled players will have a shorter reaction time in phase two and three because the execution movement becomes more automatic with time and practice. It is also assumed that the draw shot will demand more attention due to the fact that the shot is proven to be a precision shot where aiming, rock weight and position is highly important. It is believed that skilled player will have a better shot success percentage, a shorter measured distance from center in missed draw shot. Finally, it is believed that the delivery speed of the skilled group will be faster than the novice players as they have a more stable and controlled delivery which leaves the skilled players with less resistance on the ice when sliding out of the hack making them go faster.

METHODS

Participants and recruitment

Nineteen adult women and men participated in this study. Participants (aged 30-62yrs) had to be curling players in good physical health. In total nineteen participants (mean age 46.7± 8.0) completed the testing; ten from the skilled group (age = 46.8± 7.0) and nine from the novice group (age= 46.6± 9.0) (table 1).

As shown in Table 1, age and gender ratio of the two groups were similar.

TABLE 1

Table 1- Group characteristics		
	S (n=10)	N(n=9)
Age (mean±SD)	46.8±7.0	46.6±9.02
Gender (M:F)	7:3	6:3
Years curling experience (mean±SD)	12.9±7.3	1.8±0.4

S= Skilled experimental group, N= Novice experimental group

Participants were recruited in two curling clubs (Sturgeon Falls Granite Club and Cumberland Curling Club) that have been chosen based on their availability and interest in participating in the study. Two groups of participants were used for the research. The first group of nine participants was filled by subjects who had two seasons or less of curling experience. The second group with ten participants was comprised of subjects with five years or more of curling experience. One year of experience was defined in this study as a complete season of curling.

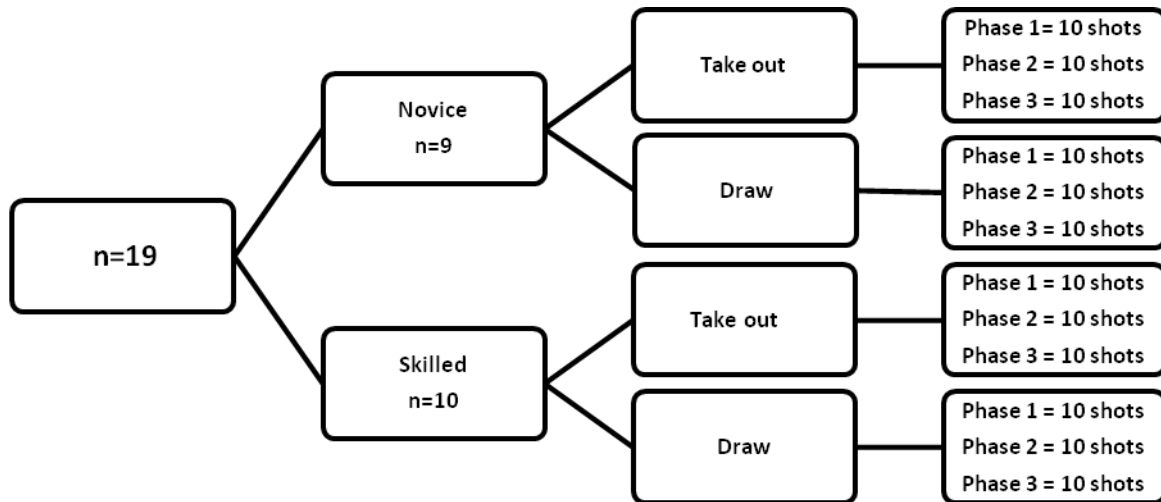
All participants were functionally able to travel to the curling clubs by car or to walk from their home. For the participants’ convenience and to prevent injuries, all participants were asked to bring their own equipment to the session. Approval from the Health Sciences Ethical Committee of the University of Ottawa was granted. All

participants were English speaking or bilingual, therefore all participants were satisfied with an English setting.

Procedures

A written consent from all the participants in the study was requested prior to stepping on the ice. The consent and protocol was in accordance with the declaration of Helsinki. Then, their age as well as their years of curling experience was collected. The experimental sessions for the expert and novice group were the same. For both groups we measured the reaction time for all shots and looked at the participant's performance based on the shot's results. Participant speed was also recorded for all players in both experimental groups. The attendance was monitored and participants were considered drop-outs if they missed the evaluation session or could not finish the session. Only the result of one participant was not analyzed because of technical problems during the evaluation; the participant's broom made too much noise on the ice causing too much interference in the audio recorder to properly analyze the voice recordings.

Experimental Design

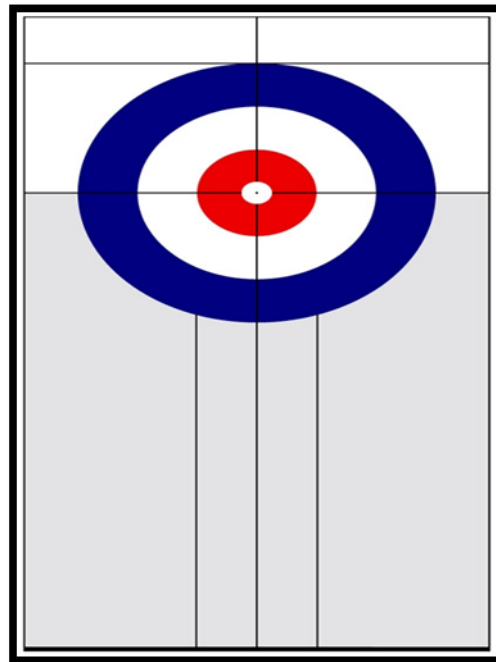


Experimental Diagram

Phase 1: Back line →→

Phase 2: Tee line →→

Phase 3: Hog line →→



Experimental Protocol

During each evaluation session, participants attended one 60 minute session. Each participant chose their session according to their schedule and all were asked to be there 5 minutes prior to the start of their session.

Prior to the evaluation session, a warm-up session was done with the participant doing two or three practice shots to get comfortable with the ice and sliding. Then 60 shots were executed with 10 shots for each of the 3 phases of the shot. The first phase of the throw will be characterized by the period in which the player comes out of the “hack” when the foot slides under the body and behind the stone. It is then that the push leg is pulled and the foot is being turned inward. The arm holding the stone is stretched out. The second phase of the throw will be when the player crosses the “t-line”. It is at this moment of the shot that the player is sliding towards the rock’s target. The third and last phase of the throw is when the player arrives near the line of Hog and is doing his final flick of the wrist to release the rock.

In all, 30 take outs and 30 draws were executed by each participant. A research assistant (the skip) was at the end of the ice calling the shot to our participants, just like you would see in a regular game as to make the shot the player’s priority. Participants were asked to complete two basic shots found in curling: the take out and the draw. For the take out, the player had to take out a rock that was situated exactly in the center of the house, right on the button. All take outs were the same throughout the experimental session. For the draw, the shot was always the same, the player having to draw to the center of the house, as close to the button as possible.

*Outcome Measures**Reaction Time and Attention*

All participants were asked to throw the rock like they would normally do in respect to the skip's orders. In addition to throwing the rock, the participants were asked to give a verbal response ("top") to a random auditory stimulus of 1000 Hz 50ms duration that was heard at one selected phase for each shot. The participants were also asked to respond as fast as they could and loud enough to be properly recorded by the voice recorder while keeping in mind that the primary task was the curling. Reaction time (RT) is defined in this study as the temporal interval between the presentation of the auditory stimulus to the subject and the onset of the verbal response (detected from the analog signal). For each shot we randomized the phase at which we let go the auditory stimulus to the subject as to eliminate any anticipation from the subject. We also had 10 control trials, 5 draws and five take outs, that were randomly placed throughout the evaluation where no sound was emitted at all as too eliminate anticipation. These control trials were not considered in the analysis.

Player Performance

All participants were asked to execute each shot to the best of their abilities. Each shot result was recorded by the skip at the end of each shot. The skip recorded if the shot was a success by writing a Y (yes) or N (no) next to the shot number on the sheet. For all take outs the outcome was only Y if the opponent's rock was taken out or N if it was not. For the draw, the outcome was Y if the rock stopped in the center of the ice on the button, the result was N the distance was then measured as to analyze by how much was the

target missed for every shot. All distances were recorded in cm with the help of a standard measuring tape. If the rock was short (did not cross the hog line) or was too heavy (went straight through the house) the longest distance was recorded which was 640cm. For each shot we randomized the kind of shot to be performed by the player as to eliminate any form of learning or anticipation from the subject.

Apparatus

To measure the reaction time of the players in this data collection we used piezoelectric loudspeakers. These loudspeakers emitted the BEEP of the response time so that the subjects could react to the stimulus. To minimize sound dispersion and change in the distance between the subject and the speaker, the latest was worn by the subjects using a belt. A MP3 recorder was used to record the beep itself and the voice of our subjects when they answered to the auditory stimuli. This way, by means of the software Audacity, we made the analysis of the response time. The recorder was also worn by the subjects, wrapped on the upper arm that was not being used to throw the rock.

Finally, laser photoelectric cells were used to record the speed of the participants for every shot. The first cell was placed at 574cm from the edge of the ice sheet; the second cell was placed at exactly 183cm from the first one. They were connected to a timing box which started the time as the participant crossed the first cell on the ice and stopped the time when the participant crossed the second cell.

The Audacity software was used for the analysis of our data, more precisely the verbal response time. It is a freeware and an open-source intended for edition, audio recording and the analysis of sounds. The other software which was used for the study is

the Statistica in which we looked at the ANOVA of our research. The Statistica software was used for the analysis of the collected data.

Statistical Analysis

A three-way analysis of variance (ANOVA) Group X Phases X Types of shot was used to compare changes in reaction time, speed and shot success, repeated measure were done with the last two factors. A two-way analysis of variance with repeated measures Group X Phases was used to compare changes in distance from center for the draw. A lowest significant difference (LSD) post-hoc analysis was used to determine the location of the differences when the ANOVA revealed significant differences with a p value smaller or equal to 0,05.

Results

Reaction Time

The three-way ANOVA for the reaction time results revealed no significant effect of Group ($F(2, 34) = 0.364, p = 0.851$), a significant effect of Phase ($F(2, 34) = 9.00, p = 0.000$) and no significant effect of Shot type ($F(2, 34) = 0.109, p = 0.075$). The three-way ANOVA also revealed no significant interaction Group X Shot type ($F(1, 17) = 0.763, P = 0.394$), no significant interaction Group X Phase ($F(2, 34) = 1.663, p = 0.205$) but showed a significant interaction Shot type X Phase ($F(2, 34) = 4.853, p = 0.014$). Finally, there was no significant three-way interaction Group X Shot type X Phase ($F(2, 34) = 0.855, p = 0.434$). Figure 1 illustrates the significant effect of Phase. A lowest significant difference (LSD) post-hoc analysis revealed that the RT for phase 1 of the shot was significantly longer than phases 2 ($p = 0.000$) and 3 ($p = 0.000$). There was no significant effect between phases 2 and 3 for the reaction time ($p = 0.05$). Figure 2 illustrates the significant interaction Shot type X Phase. A lowest significant difference (LSD) post-hoc analysis revealed a significant difference between phases 1 and 2 ($p = 0.000$) and phases 1 and 3 ($p = 0.000$) for the draw. Results from the take out revealed a significant difference between phases 1 and 2 ($p = 0.000$), phases 1 and 3 ($p = 0.031$) and phases 2 and 3 ($p = 0.012$). Results comparing shot type show a significant difference between the two shots in phase 3 ($p = 0.028$) but did not reveal a significant effect between shots in phase 1 ($p = 0.141$) and phase 2 ($p = 0.131$). The reaction times for phase 1 were longer than the reaction times for phases 2 and 3 in both types of shot, the only difference in reaction times between shot types was found in phase 3 of the delivery.

FIGURE 1

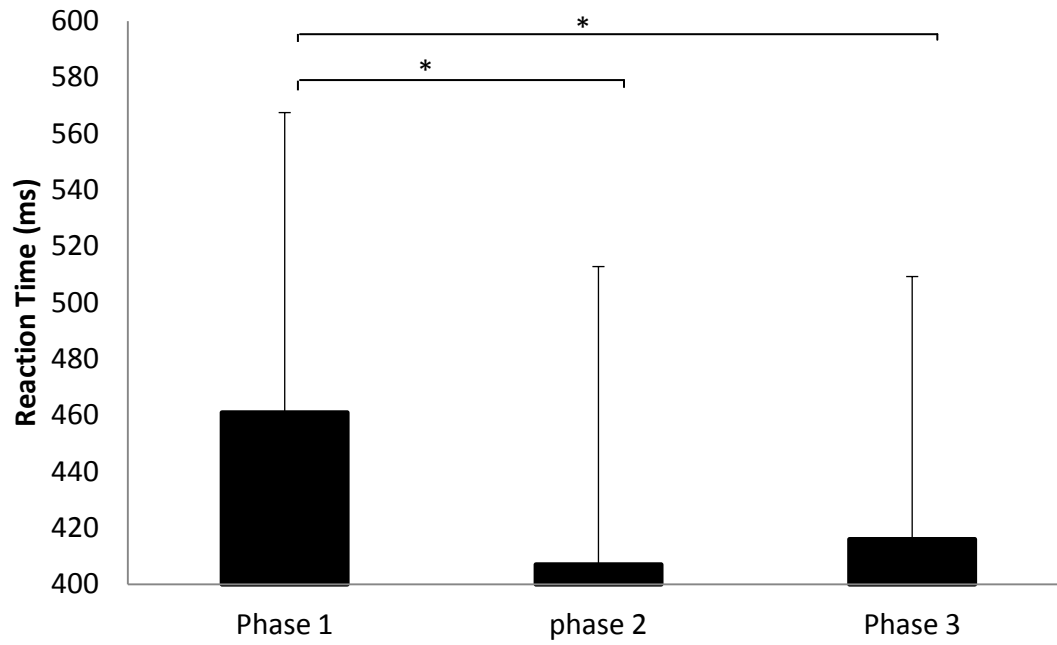


Figure 1. Mean reaction time (ms) to probe as a function of stimulus location, *= p<0.05.

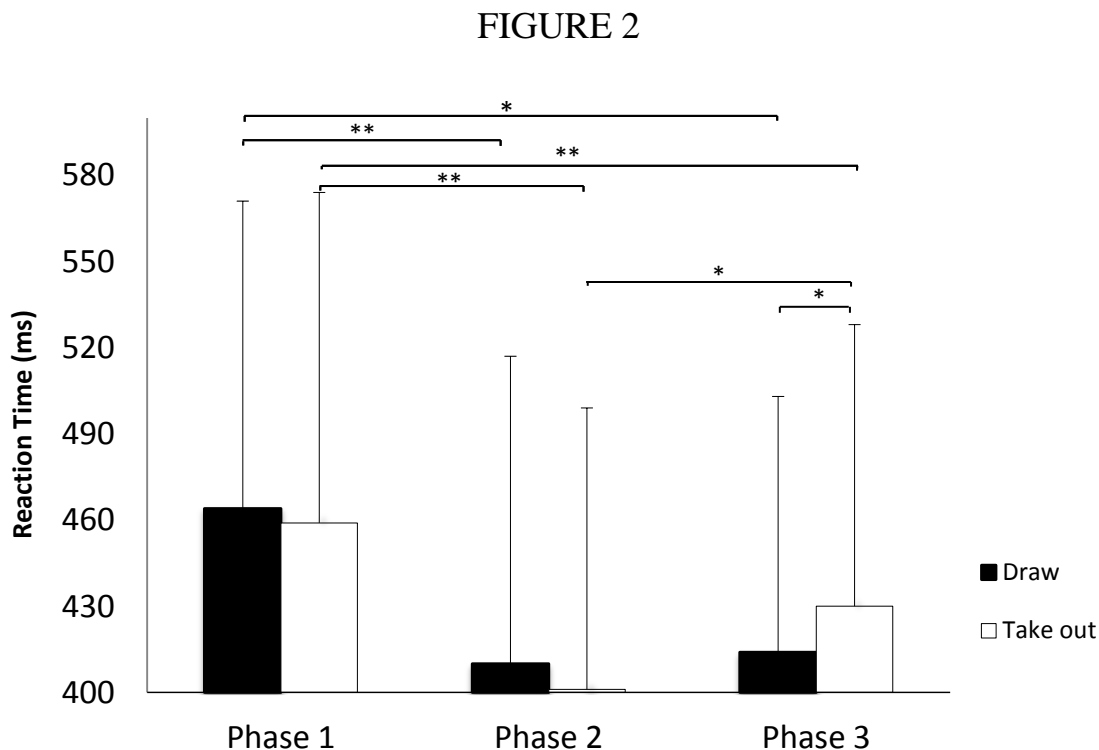


Figure 2. Mean reaction time (ms) to probe as a function of stimulus location and type of shot, *= p<0.05, **= p<0.01.

Shot success

The three-way ANOVA for shot success results revealed a significant effect of Group ($F(1, 17) = 12.60, p = 0.002$), no significant effect between Phases ($F(1, 17) = 0.742, p = 0.483$) and a significant effect between Shot type ($F(1, 17) = 155.7, p = 0.000$). The three-way ANOVA also revealed a significant interaction Group X Shot type ($F(1, 17) = 10.91, p = 0.004$) however no significant interaction was found between Group X Phases ($F(2, 34) = 0.261, p = 0.771$) and between Shot type X Phases ($F(2, 34) = 1.072, p = 0.353$). To conclude, no three-way significant effect was found ($F(2, 34) = 0.625, p = 0.541$). Figure 3 presents the shot success rate for the skilled group and novice group;

shot success was significantly higher for the skilled group than the novice group. Figure 4 presents the shot success rate for the draw and take out, shot success was significantly higher for the take outs than for the draws.

Figure 5 presents the interaction between shot success between group and type of shot. An LSD post-hoc analysis showed non-significant results between the two types of shot for the skilled group ($p=0.000$) and also for the novice group ($p=0.000$), a significant difference was found between the two groups for the take out shot ($p=0.000$) however no significant difference was found between groups for the draw ($p= 0.798$). These results show that shot success for the take out was higher than the draw shot for both groups and that the skilled group performed better than the novice group only in the take out shot and not in the draw.

FIGURE 3

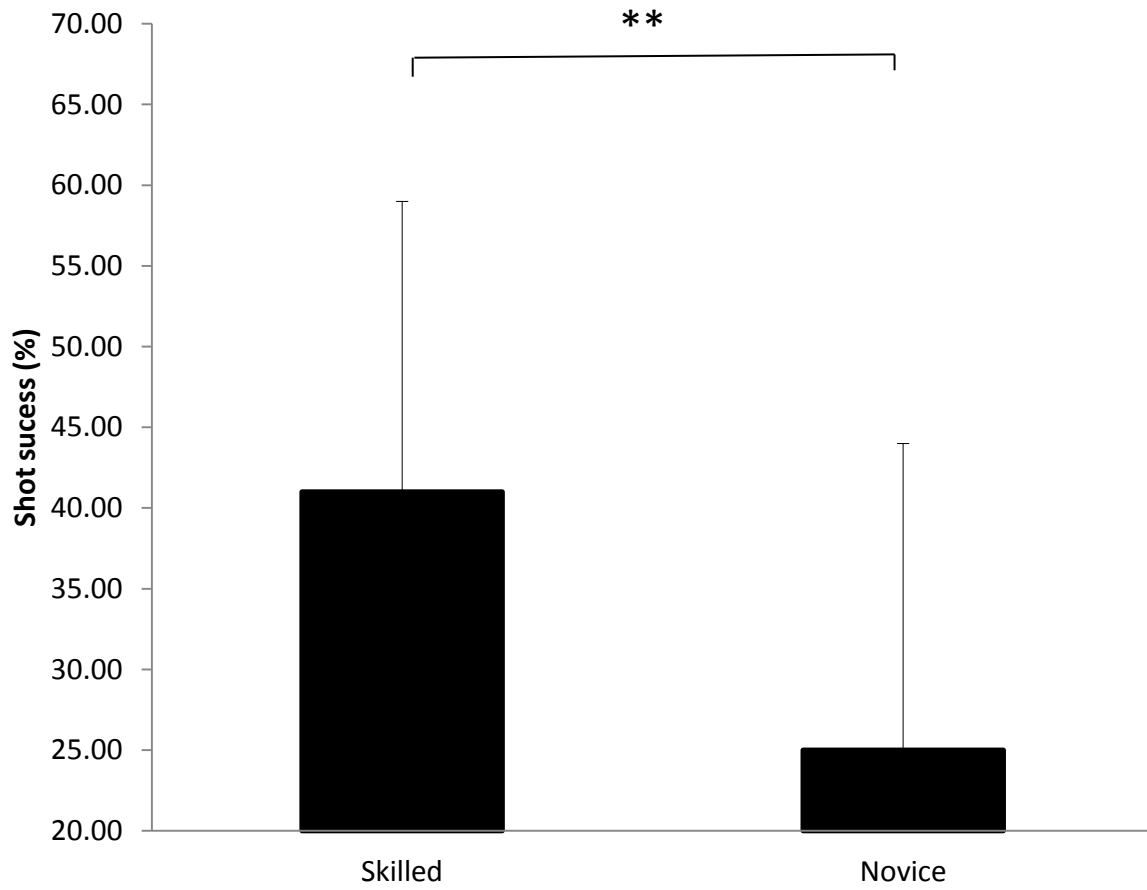


Figure 3. Mean shot success (%) as a function of skill level, **= $p < 0.01$.

FIGURE 4

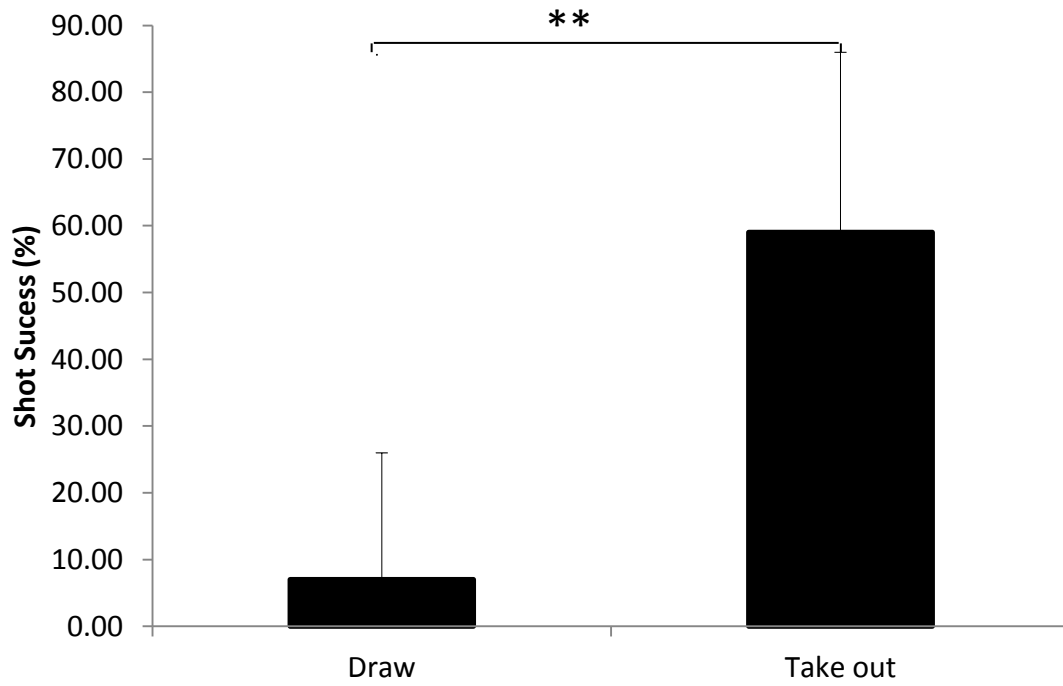


Figure 4. Mean shot success (%) as a function of type of shot, **= $p < 0.01$.

FIGURE 5

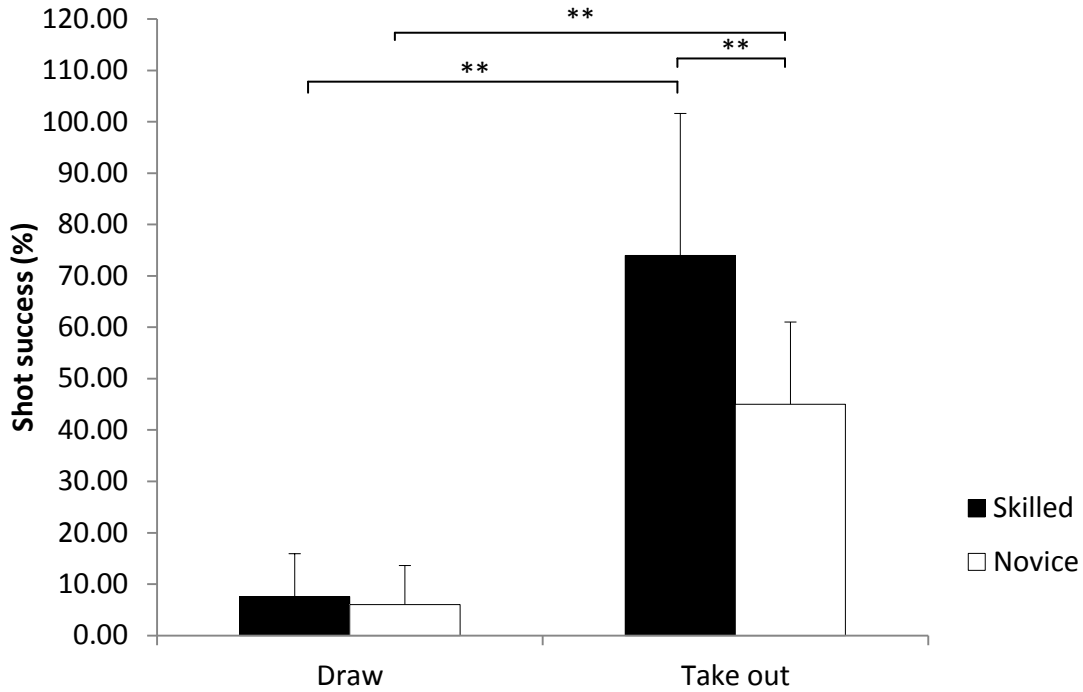


Figure 5. Mean shot success (%) as a function of stimulus location and type of shot, **= p<0.01

Distance from center

Distance was another variable which we measured in this study. Distance was measured to look once again at the player’s performance. Distance was only measured for the draw phase and represents the distance in centimeters from the button to where the rock stopped. If the rock was short (stopped before the hog line) or fast (through the house) extreme measures were given (640cm).

The two-way ANOVA (Groups X Phases) for distance measurements revealed no significant difference between Groups ($F(1, 17) = 0.041, p = 0.840$), no significant

difference between Phases ($F(2, 34) = 3.10, p = 0.06$) but a significant interaction Groups X Phases ($F(2, 34) = 3.175, p = 0.03$). Figure 6 shows the results of an LSD post-hoc analysis who revealed no significant differences between phases 1 and 2 ($p = 0.727$), phases 1 and 3 ($p = 0.786$) and between phases 2 and 3 ($p = 0.536$) for the skilled group. As for the novice group, significant differences were found between phases 1 and 2 ($p = 0.002$) and phases 1 and 3 ($p = 0.013$), no significant differences were found between phases 2 and 3 ($p = 0.437$). No significant differences were found between the skilled and novice groups in phase 1 ($p = 0.060$), phase 2 ($p = 0.067$) and 3 ($p = 0.638$). Figure 6 clearly shows that the participants of the skilled group had the same draw performance throughout all the phases while the novice group was clearly farthest from the button of the house when the stimulus was presented during phase. Differences between the two experimental groups for phase 1 and 2 of the delivery were close to being significant ($p = 0.06$), meaning that the distances from the button when the probe was presented at phase 1 and 2 of the delivery affected the novice group more than the skilled group. 1.

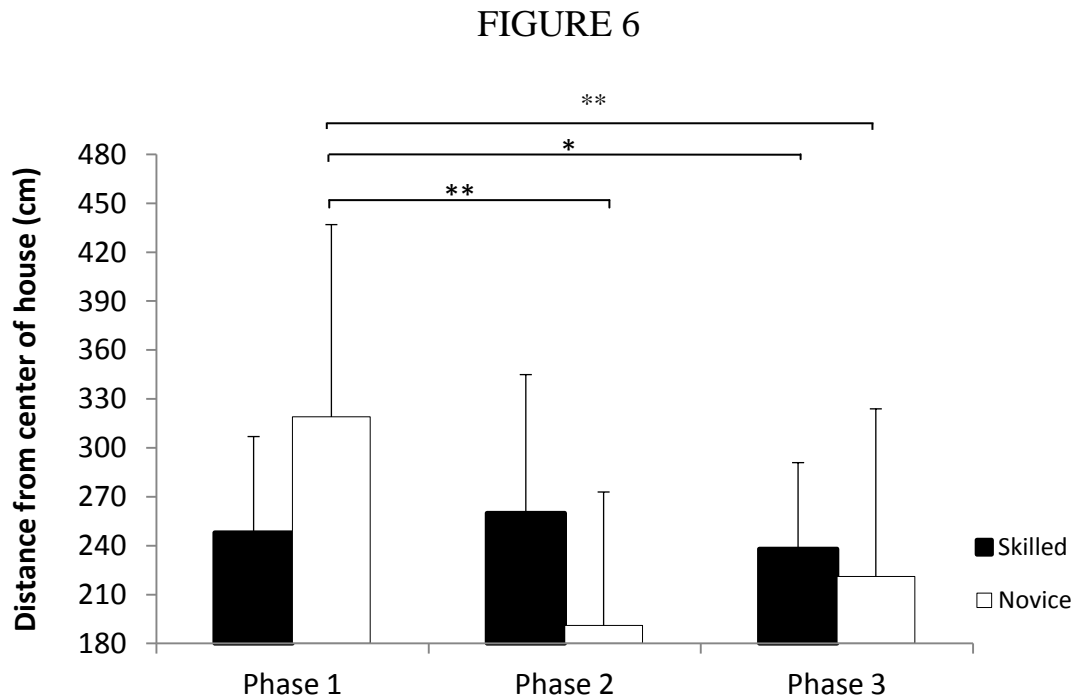


Figure 6. Mean distance from center (cm) of the house as a function of stimulus location and skill level, *= p<0.05, **= p<0.01.

Delivery speed

The three-way ANOVA (Groups X Phases X Shot type) for delivery speed revealed significant differences between Group ($F(1, 16) = 19.65, p = 0.000$), no significant differences were found between Phases ($F(2, 32) = 1.94, p = 0.159$), and a significant effect between Shot type ($F(1, 16) = 146.0, p = 0.000$). A significant interaction Group X Shot type was also found ($F(1, 16) = 17.9, p < 0.00$) (figure 7), no significant interactions were observed between Group X Phase ($F(2, 32) = 1.08, p = 0.352$) and between Shot type X Phase ($F(2, 32) = 2.66, p = 0.085$). Finally, no significant Group X Shot type X Phase interaction was found ($F(2, 32) = 0.19, p = 0.826$).

An LDS post-hoc analysis on the Group X Shot Type interaction showed significant difference in delivery speed between the draw and the take out for the skilled ($p= 0.000$) and also for the novice group ($p= 0.000$). There was also a significant difference between the two experimental groups for the draw ($p= 0.000$) and the take out ($p= 0.000$).

FIGURE 7

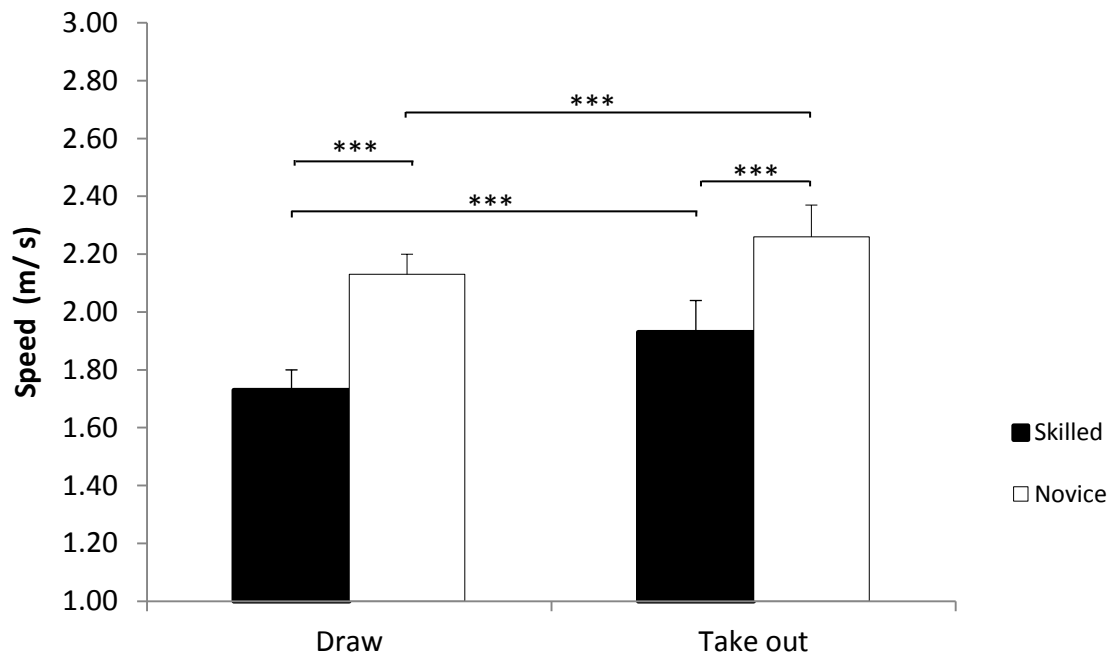


Figure 7. Mean delivery speed (m/s) as a function of shot type and skill level, ***= $p < 0.0001$.

General discussion and conclusion

The attentional demands needed for a delivery in curling are not the same across all phases of the execution. Phase 1 requires more attention than phases 2 and 3 for both groups and for both types of shot. The biggest difference between the take out and the draw was seen at phase 3 of the delivery where the take out shot showed to be more attentionally demanding than the draw. Performance differences were seen in shot success percentages where the skilled performed better than the novice and the take out shot was performed with more success than the draw. For the delivery speed, the take out was done at a faster speed than the draw and the novice group had a faster delivery than the skilled group. Distance from the center on missed draw shots showed no differences within phases for the skilled group but for the novice group distances were significantly longer when the probe was presented at the initial phase of the delivery compared to the later stages of the shot.

Attentional demands

Looking at the attentional demand element of this study, the general hypothesis was that the attentional demands would be higher at phase 1 of the curling delivery compared to phases two and three for both experimental groups. We hypothesized that the phase of departure (phase 1) would be the one that requires the most attention in both groups for the take out and the draw for the reason that several factors come into play during this stage of the shot. The regulators of balance; the muscular strength for the push as well as the attention needed to plan the sequence of movement take a lot of the

players' processing capacity at this stage in the shot. Thus we were expecting to see a slower response time for phase 1 for both experimental groups. Looking at figure 1 we can see that phase 1 of the shot does have a significantly slower reaction time than the other phases of the shot. Results clearly demonstrate that somewhat less attention is needed during the execution of the movement (phase 2) and the termination of the movement (phase 3). This is supported by the average reaction time for both groups, in phase 1 the average RT was 461ms which is a significant difference compared to 405 ms for phase 2 and 423ms for phase 3.

Using interference protocols, several authors have demonstrated similar results looking at the attentional demands throughout a controlled movement. A study by Ells (1973) clearly revealed how not all components of a discreet arm movement required the same levels of attention. In Ells (1973) study the participants sat at a table and rested their right forearm on a bar parallel to the floor pivoted at the elbow. A screen could be illuminated from behind by one of three colored bulbs: blue, red, or white. The color specified the direction the subjects were required to move the pointer. This study demonstrated that attentional demands were highest at the initiation stage of the response of moving but that these demands decreased as the arm movement progressed (Ells, 1973). In Ells' research however the attentional demands decreased even more at the termination phase which was not the case in this study. Posner and Keele (1969) concluded that when the target was small as in our study, the termination of the movement required precision. They also concluded that when the termination of a movement can be corrected, the attentional demands will depend on how precise the final position of that movement must be (Magill, 1993, Posner and Keele, 1969). Returning to

the results from Ell's study the movement that was being measured was executed at a faster speed than the curling delivery in this study. Therefore, the participants in Ell's study did not have the time to make modifications to their movement at the termination phase, this could explain the fact that their reaction time kept decreasing as the movement was progressing. Contrary to Ell's study, the movement measured in this study is done at a slower pace meaning that our subject had the time to make modifications to their slide and rock delivery and thus having a reaction time that is not gradually decreasing but more variable. Some locomotor positioning studies have revealed an increase in attentional demands at the end of a pointing movement but no such difference was found in our study (Bardy and al, 1991).

Another one of our hypothesis regarding attentional demands looked at the difference between the novice and expert groups. We believed that the biggest difference between both experimental groups was going to be at phases 2 and 3 of the delivery where we predicted the novice players would have a longer reaction time indicating higher attentional demands than the skilled curlers. It was also supposed that the novice players would show a higher reaction time in phases 2 and 3 because they would still be making changes to their delivery even after leaving the hack. We also hypothesized that the skilled players would have a shorter reaction time in phases 2 and 3 because with practice the execution movement becomes more automatic and that with practice and skill learning the shot would become more of an automatism and as the player is leaving the hack (phase 1) the shot would already have been programmed. Our results however did not show this since there was no significant difference between the novice and skilled group for the reaction times at phases 1, 2 and 3 of the delivery. These finding that

novice and skilled players do not significantly differ in reaction time suggest that perhaps the skills required for a more automatic response in a curling delivery do not emerge early or maybe never in the development of this skill as it is a very technical and ever changing task. This correlated with the findings of Hirst et al (1980) who concluded that even after extensive single task practices; additional dual-task practice was needed for subjects to perform two tasks simultaneously (Hirst et al, 1980; Schneider and Fisk, 1984). So despite the high degree of single-task practice that our skilled players may have had, these subjects could not adequately perform the dual task of delivering a rock and answering to an auditory stimulus automatically and attention-free. The results from this study also compare to those of Rose and Chrisitina (1990) who did a study on the looking at the way attention is distributed across the aiming phase of a discreet pistol shot as a function of skill levels. The skill levels that were compared in their study were novice, sub elite and elite athletes and their findings showed that the obtained probe RT is distributed similarly across all skill levels suggesting that attentional demands did not differ between groups. As with our study, the attentional demands were the same across all skill levels and no significant differences were found. The results between experimental groups obtained in this research can also be explained by the fact that the participants in our skilled group varied a lot in their years of curling experience (mean experience 17.8 ± 7.3). The skilled group had a broad range of experience with the most experienced players having twenty years of curling and the less experienced having only five. On the novice side, seven of the nine participants had two seasons of curling experience making the novice experimental group more in sync with each other in terms of results. Also, the gap in requested curling experience between the novice experimental

group and the skilled experimental group may not have been big enough making the two groups too much alike in the development of their curling skills.

Finally our last hypothesis concerning the attentional demands in this study looked at the difference in reaction time between the draw shot and the take out shot. It was believed that the draw shot would demand more attention. This was due to the fact that the shot is proved to be more of a precision shot where aiming, rock weight, rock position and ice reading is highly important and consequently more attentionally demanding for the player. Our findings from figure 2 in the two-way interaction between reactions times, for the three phases of the delivery for both types of shots hold some interesting results. As predicted the draw did have a significantly higher reaction time than the take out for the first phase and the second phase of the shot, however there were some surprising results at the termination phase of the delivery. The reaction time of the take out at the termination phase increases significantly in comparison to the second phase of the shot while the reaction time for the draw keeps decreasing throughout the entire delivery. Once again, looking at the study by Ells (1973), he concluded that in a simple reaching task that attentional demands were highest at the initial phase of the movement but that these attentional demands decreased as the movement continued. Also, the termination phase of the movement may or may not require a lot of attention depending on the requirement of the completion of the movement. Our findings for the draw shot can easily compare to those of Ells because like a simple reaching task, the termination of a draw is fairly simple, the subject simply and gently releases the rock. It is for this reason that attentional demands for the draw shot kept decreasing throughout the entire delivery. As for the take out, the study task by Posner et Keele (1969) had similar

findings to ours. They concluded that when a target is small and therefore requires a precise termination, attentional demands are higher for that phase of the movement. Also, it seemed that when the termination of the movement can be corrected, the attention needed for this task would depend on how precise the final position must be and if a correction was made at that time (Posner and Keele, 1969). The results from figure 2 can easily be interpreted using these results since the two types of shots are slightly different at the termination phase of the delivery. It was more evident when watching the novice players but almost all players did alterations to the weight of their rock at the termination phase of the shot when doing a take out. The reason for these quick changes are that at times when the players are about to release the rock they realize the speed at which the rock is going is not fast enough and thus if the rock is too slow it will curl too much and miss the target or will not take out the opposing rock. For this reason, many players will give a quick push to the rock at the termination phase of the movement when doing a takeout shot. These changes and the interpretation of the rock's weight at the releasing moment do require some processing and thus the reaction time at that phase for this type of shot is higher.

Performance variables

Shot success

For the performance variables of this study we looked at the player's delivery speed, the percentage of shot success and the distance by which the players missed their draw shots. Our first hypothesis regarding shot success was that the skilled players would perform at a higher level and have a better shot success rate than the novice players.

Figure 3 shows that there is a significant difference between the two experimental groups with the skilled players making 41% of their overall shots and the novice group making only 25% of their shots. Given that the novice players are at the more cognitive phase of the learning process their performance is usually very inconsistent and consequently less successful than those of the more advanced players. Also, these types of players being less skilled in the sport have more of an internal attentional focus meaning they are focusing on the technical aspects of the delivery and not so much on their delivery outcome. The skilled group being in the more autonomous phase had a better shot success percentage for the reason that their delivery is said to be more controlled. As a result, those types of players can expend more of their attention on external factors such as the outcome of the shot and thus obtain a higher success rate (Schmidt, 1988). Looking at the success rate in relation to the type of shot, our results (figure 4) showed that the take out shot (59%) had a higher success rate than the draw shot (8%). These results from figure 4 go with our hypothesis that making a draw to the button in curling is extremely challenging being compared to a hole in one in golf or even a half court shot in basketball. The draw to the button requires the rock's weight to be exact and the aiming to be precise, also the rock has to curl the right amount so the player has to be able to read the ice surface perfectly. In a normal curling setting where the player delivering the rock can rely on a team of brushers, the draw success rate is higher. Statistics from the Canadian Curling Association (2011) show that in normal curling phases the draw and the take out success percentage should be close to the same, however the absence of brushing in this study gave an advantage to the take out shot. Our reason for not having brushers in this study was that we were looking at the player's performance and not a

curling team's performance. Given that the rock sweepers can make a shot successful when it was not inclined to be posed problems in this study, thus we decided to exclude the sweeping from our study making the draw shot a lot more challenging. We however had some interesting findings regarding the success percentage of each experimental group in relation to the type of shot that was being performed. The findings of figure 5 indicate that there were no significant differences between the skilled and novice player when they were performing a draw shot. As mentioned earlier, this a draw to the button is considered one of the most difficult shot in the game of curling, thus even at the skilled level players still have a hard time delivering this shot successfully. For the take out, the skilled players had a significantly higher success rate than the novice players. These results are explained for the reason that skilled players have mastered the take out shot, with practice they have learned the right push force to make this type of shot and having a more balanced delivery than the novice players helps them focus more on the rock that needs to be taken out.

Distance from center

Distance was another performance variable which we measured in this study; it was measured to look at the player's performance in the draw shot. Distance was only measured for the draw phase and represents the distance in centimeters from the button to where the rock can to a stop. If the rock was too slow (stopped before the hog line) or too fast (through the house) the highest possible measures was given (640cm). For this study, if the players did not put their rock right on the button of the house the draw was considered a miss and the distance was measured. We added this variable to the study because if the players did not make their draw we wanted to know by how much was the

target missed. Results of the interaction (Group X Phase) revealed that for the skilled group there were no significant differences between the distances measured from the button of the house and the phase of where the probe was presented (figure 6). These results indicate that no matter where the probe was presented during the delivery, it did not affect the performance of the skilled player as they all had similar distances on missed draws. The interesting findings of figure 6 however were the ones from the novice group. Figure 6 clearly shows that rock stopped significantly farther from the center when the probe was presented at the beginning of the movement (mean= 319cm) compared to when the stimulus was presented at the second phase of the shot (mean=191cm) or the termination phase of the shot (mean= 221 cm). These results suggest that when the attentional demands of the shot are highest at those stages of the shot the players did had worst draw results. This could be explained by the fact that the novice players have not yet mastered controlled and balanced delivery. As seen in figure 2, the attentional demands are greatest at the initial phase of the movement and the novice players not only have a slower RT but they also miss their draw shot by more when the probe is presented to them at the initial phase of the delivery.

Delivery speed

The player's delivery speed was the last performance component measured in this study for the reason that speed influences the player's equilibrium while sliding out on the ice thus affecting the attentional load of the shot. Some interesting results were found from a two-way interaction Group X Types of shot (Figure 7). As the figure clearly demonstrates, there was a significant difference between the take out and the draw for the

delivery speed. The draw had an average speed of 1.91 m/s while the take out average speed was 2.08 m/s. These results were expected for the reason that a takeout is a shot that is delivered at high speed since its main purpose is to remove an opponent's stone from the playing surface. Contrary to the takeout, the draw is a very slow but precise shot which involves sending your stone down the ice and getting as close to the button as possible, for this type of shot the players cannot go too fast as the rock will go through the house and not count. What was interesting however with figure 7 was the significant difference between the two experimental groups. The skilled group had an average delivery speed of 1, 83 m/s second while the novice group had an average speed of 2.18 m/s his shows that the delivery speed does change with practice and time as the players get more comfortable with their delivery. The main reason that our novice group had a faster delivery speed than the skilled group is that novice players are not well balanced on the ice therefore they create more friction on the ice and don't slide as far as the skilled players do. Because novice curlers do not slide as far they need to come out faster from the hack in order to make sure the rock gets to the other side of the ice sheet. Also, skilled players have a more practiced and controlled delivery and for this reason have a better understanding of the push force required to make certain shots. For the novice players that have not obtained that knowledge yet constantly comes out of the hack at always the same speed and always faster because they cannot slide as far and as controlled on the ice causing a lot of resistance on the ice. As a result, the novice players tend to push a lot harder in the hack in order to slide far enough and to make sure the rock will make it to the other end of the ice sheet. Figure 7 confirms this analysis, there is a significant difference in speed means between the types of shots (draw=1.73m/s; takeout= 1.94 m/s)

for the skilled players has they have a clear understanding of the push force required for a draw and a takeout. As for the novice group, the difference between the means of the two types of shot is 0.13 m/s, (draw= 2.13 m/s; takeout= 2.26 m/s) which is not a big difference in compared to the other group.

Looking at the reaction time measurements and all the performance variables as an ensemble, some interesting conclusions can be made. Results showed that skilled players had a higher shot success and a slower delivery speed than the novice players. Making the relation between these results and the attentional focus of the players it is suggested that the skilled players have mastered the internal factors of the delivery and thus have their focus on the external element of the shot, directing their attention on the target, shot outcome and assuring a flowing delivery. These are all factors that have an attentional cost, adding to the cognitive demands of the delivery for this group. This could explain why skilled players had a slow delivery, a better shot outcome but still had a reaction time that was similar to the novice group. Contrary to the skilled group, the novice group has a lower shot success rates and a faster delivery speed than the skilled group. As the novice group has a more internal focus of attention, these players are a lot more concentrated on the numerous factors of the delivery like muscle force, balance, rock control and delivery steps. Thus these internal factors also have a high attentional cost and consequently, the novice players devoted their entire processing resources to the delivery itself and not the shot outcome and the surrounding environment. Consequently, we strongly believe this is why there was no significant difference between groups in the reaction time measurements of the study. The attentional demands were the same for both

groups however as the performance variables tell us the attention was not directed at the same place for both groups.

Results from this study will lead to a better understanding of the attentional demands of two key shots in the sport of Curling. Help curling coaches and teachers, as well as the players of the sport to know more about the attentional demands of the execution movement of the sport, thus helping players perfect their shots and thus increase their success in the game. We also believe this opens a new and interesting perspective on attentional demands while doing a more complex and demanding task: sliding on the ice in a position of extreme knee flexion and hip extension while aiming a heavy object towards a target. Thus, we believe these observations pose fundamental questions regarding the interdependence between the different levels of organization necessary for the execution of a more complex task; it also opens the door for future research in this great Canadian sport.

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Annex 1

Contribution of collaborators

This project is a work written and conceived by Veronique Shank with the collaboration and direction of Dr. Yves Lajoie. Yves Lajoie participated in the formation of this work and assured supervision. The data collection was conceived thanks to the participation of Yves Lajoie and Veronique Shank. These two did the data analysis for the project.



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Annex 2

Consent Form

Title of the study: Attentional Demands in the Execution Phase of Curling

Name of Co-Investigator: Veronique Shank

Institution, Faculty, Department: University of Ottawa, Health Sciences,
School of Human Kinetics

Name of Co-Investigator: Yves Lajoie

Institution, Faculty, Department: University of Ottawa, Health Sciences,
School of Human Kinetics

I am invited to participate in the abovementioned research study conducted by Véronique Shank and Yves Lajoie PhD from the University of Ottawa, Faculty of Health Sciences.

PURPOSE OF THE STUDY:

The purpose of the study is to determine the attentional demands of the execution phase in Curling.

PARTICIPATION:

My participation will consist of one testing session that will last approximately 1 hour. During this session I will have to answer 1 questionnaire and deliver curling stones while answering "TOP" to an auditory stimulus that is presented to me.

RISKS:

I understand there are some physical risks in participating in this study. Since I will have to play Curling on the ice, there is a risk of me falling or slipping.

I understand that I will be allowed to use my own equipment that I am familiar with in order to minimize the physical risks.

BENEFITS:

My participation in this study will lead to: 1) A better understanding of the attentional demands of two key shots in the sport of Curling. 2) Help curling coaches and teachers, as well as the players of the sport to know more about the attentional demands of the execution movement of the sport, thus helping players perfect their shots and thus increase their success in the game.

CONFIDENTIALITY AND DATA KEEPING:

I have received assurance from the researcher that the information I will share will remain strictly confidential. I understand that the contents will be used only for research only. The audio and all the questionnaires will be kept in a locked filing cabinet located in the laboratory of the researchers for a period of 5 years, after which they will be destroyed. The collected data will be kept on a computer accessible only to the researchers under the protection of an access code.

ANONYMITY:

My anonymity will be protected by the use of terms such as “the participant”. No names will be mentioned on any reports or documents related to the study. The researchers will use numbers to differentiate between participants.

COMPENSATION:

There is no money compensation for participating in this study.

VOLUNTARY PARTICIPATION:

I realize that I may withdraw from this study at any time, even after I have agreed to participate; without providing any reason, without consequence. If I withdraw from the study, any of my collected data will be destroyed.

MORE INFORMATION ABOUT THIS STUDY

If I have any questions about the study, I may contact the researcher or his supervisor at the numbers mentioned above.

If I have any questions regarding the ethical conduct of this study, I may contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 159, Ottawa, ON K1N 6N5

CONSENT:

I, _____, the undersigned, agree to participate in the above research study. The study has been explained to me, I have had the opportunity to ask questions about my involvement and to receive additional details that I wanted to know about the study. I understand that by accepting to participate, I am in no way waiving my right to withdraw from the study at any time.

There are two copies of the consent form, one of which is mine to keep.

Participant's signature: _____ Date: (Date)

Researcher's signature: _____ Date: *(Date)*

Annex 3

Attentional Demands in the Execution Phase of Curling Letter of Information

Introduction:

The present research attempts to explore the essential level of attention at every phase of execution of the shot for beginners and experts at the sport. Moreover, it will examine and compare the attentional costs of the two traditional throws in Curling, the take out and the draw.

Research Procedures:

If you agree to participate in this study you will be asked to come to the curling club at your assigned time, your session will last approximately one hour. At the beginning of the session we will give you a few minutes to get ready in your curling gear. During this time, you will be asked to fill out a Health Status Questionnaire and the consent form for the study.

You will then undergo a control sitting reaction time trial (10 trials) before stepping out onto the ice.

We will then go to the ice surface where you will be doing two or three practice shots to get comfortable with the ice and sliding. Then 40 shots will be executed with 10 shots for each of the 3 phases of the shot. In all, 20 take outs and 20 draws will be done. There will be a skip at the end of the ice calling the shot and marking the results of each shot, just like you would see in a regular game as to make the shot the player's priority.

In addition to throwing the rock, you will be asked to give a verbal response ("top") to a random auditory stimulus of 1000 Hz 50ms duration that will be heard. For each shot we will be randomizing the phase at which we let go the auditory stimulus to the subject as to eliminate the anticipation from the subject.

After your 40 shots you will be asked to do another reaction time trial (10 trials) after stepping off the ice.

Apparatus

To measure the reaction time in the collection we will be using piezoelectric loudspeakers. These loudspeakers will be used to emit the BEEP of the response time so that you can react to the stimulus. To minimize sound dispersion and change in the distance between the subject and the speaker, the latest will be worn using a belt. Laser photoelectric cells will be used to precisely trigger the stimuli in the different phases. Finally, we are going to use a MP3 recorder that is going to record your voice when you answer to the auditory stimuli. The recorder will be wear by the subjects on the shoulder that is not used to throw the rock

Equipment

For this study you will be able to use your own curling equipment to help prevent injuries and to make you more comfortable on the ice.

Risks

I understand there are some physical risks in participating in this study. Since I will have to play Curling on the ice, there is a risk of me falling or slipping. I understand that I will be allowed to use my own equipment that I am familiar with in order to minimize the physical risks.

Participant Exclusion Criteria

Exclusion criteria will include individuals who have injuries preventing them from playing curling, have any neurological impairment and have not played curling in the last year

Confidentiality

Any information obtained from this study will be kept confidential. Any data resulting from your participation will be identified only by case number, without any reference to your name or personal information. The data will be stored on a secure computer in a locked room. Both the computer and the room will be accessible only to the experimenters. After completion of the experiment, data will be archived on storage disks and stored in a locked room for five years, after which they will be destroyed.

Estimate of participant's time and number of participants

Each experiment will last approximately one hour.

Consent form

If you wish to proceed with participation, you will be asked to sign and date a form indicating that you have read this letter and agree to participate.

Contact Information

** If you still wish to participate in this study please give us (or respond to this e-mail giving us) your age and how many consecutive years of curling experience you have. If you have any questions about your rights as a research participant or the conduct of the study you may contact:



uOttawa

Faculté des sciences de la santé
Faculty of Health Sciences

Annex 4

Volunteers Needed

Researchers from the School of Human Kinetics at the University of Ottawa are conducting a study to investigate the attentional demands in the execution phase of Curling in adults 40-60 years old. Experience needed is 2 or less consecutive seasons.

The study will be held at Cumberland Curling Club. Qualifying participants will be asked to attend a one hour session where they will be asked to throw some rocks while answering to an auditory stimulus.

If you are interested in participating and would like more information please contact:

Véronique Shank

Yves Lajoie, PhD.

**Université
d'Ottawa**

Faculté des sciences
de la santé

École des sciences
de l'activité physique


**University of
Ottawa**

Faculty of Health
Sciences

School of Human
Kinetics

Annex 5

File Number: H09-10-05 **Date (mm/dd/yyyy):** 10/12/2010



Université d'Ottawa **University of Ottawa**
 Bureau d'éthique et d'intégrité de la recherche Office of Research Ethics and Integrity

Ethics Approval Notice
Health Sciences and Science REB

Principal Investigator / Supervisor / Co-investigator(s) / Student(s)

<u>First Name</u>	<u>Last Name</u>	<u>Affiliation</u>	<u>Role</u>
Yves	Lajoie	Health Sciences / Human Kinetics	Supervisor
Véronique	Shank	Health Sciences / Human Kinetics	Student Researcher

File Number: H09-10-05

Type of Project: Master's Thesis

Title: Attentional Demands in the Execution Phase of Curling

Approval Date (mm/dd/yyyy)	Expiry Date (mm/dd/yyyy)	Approval Type
10/12/2010	10/11/2011	Ia

(Ia: Approval, Ib: Approval for initial stage only)

Special Conditions / Comments:
 N/A

