OBSERVATIONAL VARIABILITY: THEORETICAL AND APPLIED CONSIDERATIONS

THE IMPACT OF VARIABILITY IN OBSERVATIONAL PRACTICE ON SKILL LEARNING: THEORETICAL AND APPLIED CONSIDERATIONS

BY

ARTHUR MICHAEL WELSHER, H.B.Sc.Kin

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AUTHOR: Arthur Michael Welsher H.B.Sc.Kin (McMaster)

SUPERVISOR: Dr. Lawrence Grierson

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ABSTRACT

There is strong evidence that certain neurophysiological processes link action and observation (Higuchi et al., 2012), which supports the idea that learning a motor skill is enhanced via skill observation (Hayes et al., 2010). Skill learning through observation is optimized when the observation includes a combination of expert and novice models (Rohbanfard and Proteau, 2011). The purported advantage lies in the two types of models' dissimilar ability (Andrieux & Proteau, 2013). The novice model is characterized by larger margins of error that manifest as variable attempts. Increased variability has been shown to be beneficial in physical practice (Moxley, 1979). The purpose of the first study was to examine the observation of novice variability effect to explore whether it is Schmidt's (1975) generalized motor programs or schema parameterization representations that is acquired when observing modeled performances. Participants engaged in an observational period in which they observed a criterion model with no variability, a model demonstrating absolute timing variability, a model demonstrating relative timing variability, or a model demonstrating variability in both relative and absolute timing. The results indicate that variability in relative timing information contributes to observational learning, which suggests that generalized motor programs are acquired through observation but not schematic parameterizations. The purpose of the second study was to apply the Rohbanfard and Proteau (2011) paradigm in the medical education context by exploring the impact of video-based observational practice on the clinical learning. First year medical students learned a common surgical skill by observing expert

demonstrations of the skill, novice demonstrations, or demonstrations by both an expert and novice model. The study demonstrated a robust effect of observational learning in that all groups improved over time regardless of the type of model they observed. Both studies highlight that an expert model may be the most beneficial when engaging in observational practice.

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CHAPTER I: REVIEW OF LITERATURE

1.1 Preamble

In order to learn a motor skill, such as shooting a free throw or swinging a golf club, one must practice the skill to improve. There are two main perspectives that hypothesize how individuals are able to acquire and refine motor skills; constraints-based view and information processing approach (see review for a comparison Anson, Elliot & Davids, 2005). Constrained-based theory believes that individual's movements emerge by attempting to coordinate degrees of freedom to achieve a goal which is constrained by the organism, environment, and task. The emergent pattern is thought to diverge from a variable unstable state to a pattern in which the degrees of freedom are coordinated to achieve a stable state. This thesis will take an information processing perspective however it is important to acknowledge that other competing theories exist. Through experience learners are thought to store vital memorial information that is used in subsequent performances of the skill. One of the most influential and prevalent theories in the information processing perspective is Schmidt's (1975) Schema Theory. This literature review outlines the Schema Theory and empirical evidence that has guided information processing perspectives of motor control and learning research over the last 50 years. After which, the review highlights learner progressions and educational strategies that can facilitate skill acquisition. The review then transitions into a more specific discussion on the observational learning of new motor skills. Similarities and comparisons between physical practice and observational learning are drawn, and gaps within this area of research are introduced.

1.2 Memorial Representation

Information processing holds that memories are important in the way we experience our environments, and this includes the way we learn a new motor skill. One example that illustrates this point is a study performed by Henry & Rogers (1960). They believed that we stored representations of movements in a "memory drum" and, when we wanted to execute a movement, we would need to retrieve the memory in order to perform it. They hypothesized that a memory would be larger if the task was more complex and this would manifest itself in the time it takes to initiate the movement. To test this, Henry and Rogers had participants perform three physical movements that increased in complexity, which they defined as the number of component actions that constituted the task. The first was simple finger lift. The second was a finger lift followed by a snatching task in which they had to grab a ball suspended in mid-air. The third movement involved changing directions and hitting three targets after the initial finger lift. Their main dependant measure was simple reaction time, which is the time that elapses from a stimulus signaling the start of the movement to the initiation of that movement. They illustrated that as the task complexity of the movement increased, so did the reaction time to initiate the movement. This finding demonstrates that the central processing that proceeds a movement is a function of the movement's complexity, and stands as strong evidence that movements are represented centrally as memories. This idea is also reflected in the way that a skilled performance shares similar characteristics across effectors. This is evident in the way we generate similar signatures with either our dominant or non-dominant hand (Lashley, 1930).

1.3 Schema Theory

Schema Theory (Schmidt, 1975) explains how these memories are formed and what information they contain. At the core of the theory is the idea that we store two forms of motor representations. The first are called generalized motor programs, which contain the invariant features of a movement; such as, relative timing and relative force. These are thought to be generalized to a given class of movements so that one motor program can be used to perform a particular kind of movement in a variety of different ways and under different environmental constraints (Schmidt, 2003). This concept solved one of the major problems of previous theories: storage. Previous theories (Adams, 1971, for example) postulated that we store a memorial motor program for every movement executed, which would mean that we would require an immense amount space within our central nervous system.

The second representation is the schema, which is a set of rules that are developed over performances of a skill. The schema describes the relationship between previous outcomes and the parameters that were associated with that attempt (Schmidt, 2003). In particular, the schema stores four main things. The first is the initial conditions. This involves information about the individual's body as it relates to itself and the environmental information and includes information from all of our senses. The second is the response specifications that were applied to the motor program to execute that movement; such as, speed and force. The third piece of information is the sensory consequences that were associated with the movement, which are the afferent information the individual receives during the movement performance. The final piece is the response outcome, which involves a comparison of the expected outcome with what actually occurred.

When we examine a movement the generalized motor program defines invariant features of a task; such as relative timing or the time that elapses between multiple sequential portions of a movement. In the context of an overhand throw, it is the relative joint co-ordination over the course of the movement. In a serial task, such as a multi-segment tapping task: the invariant features might be the time between each segment in relation to the other segments. While absolute time or the time that elapses over the entire movement, would be defined by the schema. Schematic representation allows the appropriate parameters to be applied to achieve the absolute goal. In the context of the overhand throw being able to do the movement in a shorter absolute time would allow you to throw the object further.

Through experience and practice, the schema for a particular movement thought to strengthens. Practice allows the learner to abstract the four pieces of information that are stored into one array more often and allows her/him to associate the right response specifications with the appropriate initial conditions to reach his/her outcome goal. Every time the movement is performed correctly and the appropriate feedback is received, then the schema improves. One of the main issues with previous theories was that they couldn't explain how an individual was able to create novel movements. This notion of schema lends itself well to this problem because, as the schema strengthens, the individual is able to extrapolate the response specifications to accommodate changes in initial conditions as s/he often does in real life situations.

1.4 Feedback and Online Control

One of Schmidt's hypotheses was that through experience we used feedback to make associations between outcomes and response specifications, and in turn strengthen the schema. Importantly, Schmidt believed that this feedback was used in the initial stages of learning to develop the representation but, as it became stronger, we would rely less on feedback and the motor program would eventually be performed without feedback at all (Schmidt, 1976). A study by Wadman and colleagues (1979) demonstrates this idea nicely. They were examining how the central nervous system functions when executing a motor program and had participants perform a rapid elbow extensions movement to a target, but at random attempts, blocked the participant's arm so that it could not physically move to the target. The compelling data from this study is that the EMG traces of the participants' antagonist and agonist activations about the elbow were very similar in both the blocked and unblocked conditions. That is, whether or not the arm was actually moving, the motor program still ran its course, suggesting seemingly that once centrally-stored, preprogrammed muscular commands are initiated that they complete their course regardless of feedback.

This idea came under contention and a study by Proteau, Marteniuk, Girouard and Dugas (1987) demonstrated that the opposite is true. One of the main goals of the study was to see if those who trained extensively with vision in a rapid aiming task would be able to perform equally well when vision was removed. They had four groups: two of which practiced the rapid aiming task for 200 trials and the other two for 2000 trials. Within each group, half practiced with complete vision of the moving limb and the target

(L+T) and the other half with only vision of the target (T). After the acquisition phase they all performed a transfer task where only the target was visible. Looking at root mean square error of the difference between the pre-transfer to transfer performance, the experimenters noted that those in the complete vision condition suffer more in the transfer. They recorded a 100% increase of RMSE in the L+T-200 compared to only 67% in the T-200 group. The difference was much larger within the 2000 trial groups. The L+T-2000 group has a 400% increase in RMSE while the T-2000 didn’t increase at all. This demonstrates two important points. Firstly, there is specificity to learning and that when you practice under certain conditions you become more efficient at using the specific information available to complete a task. Secondly, the results demonstrated that those that practiced the task extensively in the full vision group were affected to a much greater degree when vision was removed. This demonstrates that as we practice a skill we become more reliant on feedback and we are better able to use different sources of feedback. Had Schmidt’s hypothesis about the use of feedback with experience held up, we would have seen that even though visual feedback was removed the 2000 L+T group would have performed equally well; as their motor program would have been able to run its course in an open-loop manner.

The processing of concurrent intrinsic feedback is a critical part of movement success because it allows us to minimize the impacts associated with neuromuscular noise, which creates inefficiencies and can cause errors in movement outcomes. We see that as we produce forces with our limbs that there is an inherent variability in the outcomes of the movements. This variability follows a relationship that as the force being produced increases there is a proportional increase in the spatial variability, and potentially error, toward the end of the movement (Meyer et al., 1988; Schmidt, 1979). This increase in force may be required when the movement is performed quickly or when a greater distance needs to be covered (Fitts, 1954). For example, when reaching for an object we are able to use concurrent feedback from our sensory sources to make fine adjustments to minimize the impact of the noise. One of the main goals when learning a skill is to strategize around this noise.

Rapid aiming paradigms have been used extensively to examine how we complete quick precision movements and deal with this inherent variability. There are several models or theories that explain how we execute a reaching movement. One is the optimized submovement model which believes that this inherent noise within our reaching movements manifests itself in a normal distribution of endpoints of our primary and secondary movements (Meyer, Abrams, Kornblum, Wright & Smith, 1988). If the goal was to centre movement endpoints directly on our target, then our aiming movements should overshoot the target centre as much as undershoot it. However, this is not the case. Rather, the movement endpoints are distributed short of the intended target. The explanation for this returns back to the idea of using intrinsic sensory feedback during a movement. Woodworth (1899) was one of the first scientists to examine the importance of intrinsic feedback, specifically visual, on goal directed aiming tasks. His study had individuals making rapid aiming movements back and forth between two targets with a pencil on a piece of paper that was attached to a rotating drum. The targets varied in distance but he also had them perform the task at varying speeds. Looking at the time-displacement profiles created on the paper it was concluded that individuals make an initial impulse movement and then before they reach the target make a second “homing” movement that uses feedback to adjust for any error (see also Elliot, Chua & Helsen, 2001). Woodworth also had these individuals perform the task with their eyes open or with their eyes closed. He found that there was increased error in the no vision condition but as the individuals began to perform the task quicker and quicker the vision trials approached the same amount of error as the no vision trials. As they performed the task quicker, they approached a speed where only the first impulse phase was completed and the second homing phase could not be used because the task was completed before visual information could be processed. This was the first demonstration of the minimum time that our central nervous system requires to process and use visual feedback.

This ties back into why we don’t see a normal distribution centered over the target, with respect to our end point variability, when performing an aiming task. What actually occurs is we have a tendency to undershoot the target with our primary movement (Carlton, 1979). This occurs for several reasons. Firstly, it is more economical with respect to energy consumption. If we undershoot then we simply make a secondary movement in the same direction which minimizes the distances traveled. Compared to a situation where we passed the target, then had to do a secondary movement to backtrack, which would result in a larger distance travelled. Additionally, to move in the opposite direction of the target after an overshoot you must overcome your initial inertia to switch directions which is more costly with respect to energy. Finally to switch directions in an overshoot you must now activate your muscles in a different pattern to cause your limb to move in the opposite direction than when you began. Target undershooting is one of many strategies that individuals use as they become more efficient at a movement in order to minimize the impact of inherent variability of their neuromuscular system on their movement outcomes.

1.5 Learning

Individuals that have committed enough time and effort may become so proficient in a particular skill that we may label them an expert. It has been postulated that it requires a minimum of 10 years or 10, 000 hours of deliberate practice to achieve (Ericsson, Krampe and Tesch-Romer, 1993). It is thought that during these hours, learners proceed through a set of characteristic stages that are captured adequately by Fitts and Posner (1967). Their Stages of Learning begins with a cognitive stage in which the learner attempts to understand the basic workings of the movement, often by verbalizing the movement mentally. This stage is characterized by errors and inconsistent performance. However, the greatest improvement is also seen during this stage. The next stage is the, associative stage where learners attempt to refine the movement and begin to adjust their attention to other cues in the environment. The movement becomes more consistent and learners are able to correct their errors while focusing on different environmental cues. Finally, if the learner has created a robust representation, s/he may reach the autonomous stage, where the movement appears automatic and additional tasks can be performed simultaneously (Haibach, Reid and Collier, 2011). In this stage few errors are performed and the learner is able to react to changing environmental constraints.

Differences in skill level can manifest in a variety of ways depending on what is required in a particular situation. For example, one study compared individuals who practiced karate and assigned their skill level on the colour belt they had achieved (Kim & Petrakis, 1998). The researchers tested the participants' visuoperceptual speed using the identical pictures test and found that those in the autonomous stage (black belt) scored significantly higher than those in the cognitive (white belt) or associative stage (blue belt) (Kim & Petrakis, 1998). Although, one cannot conclude cause and effect, it seems that with practice the individuals are able to perceive things in their environment more quickly. This is important in activities where the environment is constantly changing and quick decision making is a key to success. All of this ties back into the idea that as the representation is refined, a learner is able to use the intrinsic feedback more efficiently to complete the movement.

1.6 Observation

Researchers have always looked to new approaches of learning and alternative methods of teaching. One such route is a technique which has been used by learners throughout time and that is observing others performing a skill. We begin to utilize observational learning as soon as we are born, attempting to emulate the movements that those around us are producing (Huang & Charman, 2005). As we age, it becomes a non-verbal manner in which we acquire skills in our daily lives (Nielsen, 2006). There is both behavioural and physiological evidence that supports the use of observation for acquiring new motor skills.

Mattar and Gribble (2005) performed several studies to evaluate the role that conscious strategy and the motor systems play in observational learning. They utilized a paradigm in which the participant would grasp the end of a robotic device that guided an on-screen cursor to variety of targets. While they performed the motion to the various targets a force field was applied that would perturb their motion during the reaching movement. The amount of force applied was a function of the velocity of the reaching motion. They attempted to assess what role conscious strategy plays when engaging in observational practice. They had two groups who observed a model moving the robotic arm in a clockwise manner towards a target while being perturbed. One of the groups did this but also while simultaneously performing a distracter task where they had to perform arithmetic. This put a strain on their cognitive effort and working memory during the observation. They measured the amount of curvature or perpendicular displacement during the movement as it compared to a control group that did not observe any model. They found that there was no significant difference in performance between the two groups demonstrating that observation is not based on conscious strategy. This conclusion is drawn because the distracter group which was cognitively strained would not have been able to formulate a conscious strategy due to the cognitive strain.

The second portion of the Mattar and Gribble (2005) study attempted to assess the role of the motor system in observational learning. The paradigm was the same but instead of an arithmetic distracter, the distracted participants performed circular motions with their arm while watching the model. They found that this group performed significantly worse than the group that simply observed the model. There was a significant increase in the amount of curvature of the movements performed by the motor distracter group. These two studies are demonstrating that when we observe a model we are able to learn a novel task without conscious awareness. It seems that observation of a model performing a motor task implicitly engages the motor system.

There are a large amount of behavioral studies that demonstrate that participants are able to acquire and learn new motor tasks by observing others (Hayes et al., 2013; Larssen, Ong & Hodges, 2012; Ste-Marie et al., 2012). This is likely possible due to the link between action and perception within our central nervous system. Physiological studies have identified mirror neurons, which are neurons that discharge both when performing a goal oriented task and while observing someone else complete the task (Pellegrino et al., 1992). Furthermore, human brain imaging studies have demonstrated the existence of a several neurophysiologic regions, in the primary motor cortex and pre-motor cortex, which link action processes directly with perceptual processes. (Cross et al., 2009; Higuchi et al., 2012; Buccino et al,. 2001; Dushanova and Donoghue, 2010). These links may be responsible for human capacity to learn novel movement patterns by observing others perform.

Behaviorally though, it seems that observational learning shares many similarities with physical practice. One example is that learning is promoted in both methods of acquisition when augmented feedback regarding results is given less frequently, which translates to better retention (Badets and Blandin, 2004). In addition, observational learning can be as robust as physical practice and is not limited to the spatio-temporal characteristics of the observed visuo-mapping and a more general motor procedure can be acquired, facilitating transfer (Hayes et al., 2010).

1.7 Impact of Task Characteristics

There are a variety of factors that influence the effectiveness of observational learning, such as model type, task characteristics, autonomy, and model-observer interaction. There are three main categories that a movement could be classified under: discrete, continuous, and serial. A discrete task involves an action that unfolds rapidly and has a distinct beginning and end. A serial task is a skill that involves several discrete tasks linked together with the order of the tasks being crucial to successful performance. A continuous task does not have a defined beginning and end. It unfolds in an ongoing and often repetitive manner (Schmidt & Wrisberg, 2008). When examining observational learning studies that used discrete tasks, such as throwing or kicking a ball, the findings do not demonstrate much of an advantage when attempting to acquire the new skills. A study using a soccer chip as their movement goal found no benefit of watching a national level model as compared to a point light model or control with respect to accuracy (Horn, Williams & Scott, 2002). Similar results have been found when learners observed a variety of models performing a dart throw. It was found that participants that engaged in observation performed no better than those that had no prior task experience (Weir & Leavitt, 1990). However when looking at studies that used continuous and serial tasks the results seem to be more consistent. We see more consistent benefits of watching a model performing either a continuous or serial task, when attempting to later perform the same motor task. Many studies have used a free-standing balance ladder, in which the participant has to climb up as many rungs as they can (Feltz, 1982; Feltz & Landers, 1977). This is an example of a continuous task. One study that employed this task found that participants who viewed either a skilled or unskilled model significantly outperformed a control that did not engage in observational learning (Landers & Landers, 1973). When looking at tasks that employed serial tasks such as barrier knock down tasks and segmented timing tasks we see increased positive results. A study that had participants learn a four-segmented timing task found that observation of a model facilitated the acquisition of the task above and beyond a control (Rohbanfard & Proteau, 2011). Additionally, once all the observational groups were exposed to a period of physical practice the group that observed a combination of expert and novice models outperformed a group that only engaged in physical practice (Rohbanfard & Proteau, 2011). Therefore task characteristic can impact how learners react to observational learning and that observation benefits serial tasks the greatest followed by continuous task and the least benefit is seen in discrete tasks (Ashford, Bennet & Davids, 2006).

1.8 Outcome Goal and Autonomy

The goals of the task and how success is rated can impact how effective observation is at facilitating learning. When the goal of the skill is simply to perform the movement (Scully & Carnegie, 1998) and there is no explicit outcome goal, then observation may be a more powerful tool for learning. In a study of observational lawn bowling learning, Hayes and colleagues (2007) had half of their participants watch closely with the instructions that they would need to copy the model's movement exactly. The other half also had to replicate the movement as their primary goal but was told that this would lead to accurate outcome goals, which was somewhat of a secondary goal, as the second group was also expected to roll a ball to a 6 meter mark. The first group observed and practiced the task with no ball, while the second group used a ball. Implementing the ball creates an outcome goal which allows a comparison to how participants are able to learn a movement with and without an outcome goal. When both groups' movements were analyzed the group that didn't use a ball had better overall movement pattern (Hayes, Hodges, Scott, Horn, & Williams, 2007). This demonstrates that the presence of an outcome goal hindered the acquisition of a new motor movement. This may be due to the fact that outcome goals are prioritized over movement goals, which leads to movements being adjusted in an attempt to achieve the outcome goal. Similarly looking back on the study that had participants learn a chip soccer shot, although the learners were not able to kick the ball more accurately after watching a model they did perform the movement more like the model (Horn et al., 2002). This leads us to believe that observation allows the learner to acquire the temporal factors of the movement but this may not always lead to better outcomes.

Another important factor is the concept of autonomy. When learners are able to select when videos are observed, they are able to retain a motor skill to a higher degree (Ste-Marie, Vertes, Law & Rymal, 2013). This ability to select what and when an action is observed encourages learners to search for the optimal task solutions (Wulf, Clauss, Shea & Whitacre, 2001). We see that this combination of observation and self-control can be a powerful tool. One study had participants learn a free throw shot, which is a skill seen in basketball (Wulf, Raupach, & Pfeiffer, 2005). They had two groups: a self-control group that could request to view an expert video of the skill at any time during the acquisition of the skill, and a yoked counterpart group that viewed the videos at respective times that matched up with a participant in the self-control group. After 7 days a retention test was performed where the self-control group significantly outperformed the yoked group. The interesting aspect is that the self-control group requested the video at a very low frequency (5.8% of the practice trials). This demonstrated that the combination of autonomy and observation, even in small doses can create larger differences in learning (Wulf, Raupach, & Pfeiffer, 2005). Another study found that the participants requested viewing before 9.8 % of their attempts which demonstrates that frequency of self selection varies with respect to task characteristics and between individuals (Wrisberg & Pein, 2002).

1.9 Model

Although physical practice and observational learning share many similarities one large difference is the information that the observer receives is dependent on the type of model they view. Model characteristics can influence how efficiently learners acquire a new skill and from an information processing perspective it is in turn impacting how the action representation is formed, specifically the level of expertise of the model. Studies have demonstrated that both experts (Heyes and Foster, 2002) and novices (Weir et al., 1990) are effective models for observational learning. One study of interest was performed by Buchanan and Dean (2010) who had participants learn how to trace a pair of circles with a 90 degree relative phased pattern between their arms. Each participant was either given the role of a model or observer. The model completed two days of physical practice while the observer watched. All participants were naive learners or novices. The pairs were assigned to either an instruction or no-instruction group. The instruction group was explicitly told what strategy to use when performing the task. While the no-instruction group was not given any information about what strategy to implement and every model within this group attempted all possible strategies. The model practiced the task over two days while the observer watched. Upon returning for retention it was found that the no-instruction observation group had significantly less relative phase error than the instruction group. Indicating that although both observational groups improved while watching a novice model, the trial-to-trial variability seen within the no-instruction model enhanced observational learning.

Pollock and Lee (1992) compared models with different skill levels to analyze the effects on observational motor learning. They had participants learn a tracking task in which they had to direct an arrow around a track as if they were attempting to run around it. If they avoided the edges of the track the arrow would increase in speed and if they hit the sides it would slow down. The program would provide them a score which was dependant on how quickly they completed the task. Participants were randomly placed in a group that observed a skilled model or a learning model. They found that after an observational period the two groups performed equally well. But both groups received scores that were higher than the learning model. It seems that neither model seems to confer an advantage over the other. However a limitation of the study is they only tested the participants immediately after the observation period. Without a retention test we cannot make any conclusions on which group learned the task better. Similar results are seen when observation is used to learn a non-laboratory task, such as a sport skill, we see the same outcomes with both an expert and novice model (McCullah & Meyer, 1997). The type of model observed that affords the learner with the most information to acquire a new skill may depend on factors such as task characteristic or the performer's stage of learning.

Rohbanfard and Proteau (2011) took another approach to solving the conundrum of which type of model was best. They used a relative timing task in which the participant had to knock four blocks over with their hand to achieve absolute and relative time goals (Figure 1). There were 5 experimental groups: physical practice group (PP), observation-novice (ON), observation-expert (OE), observation-mixed (OM), and a control.

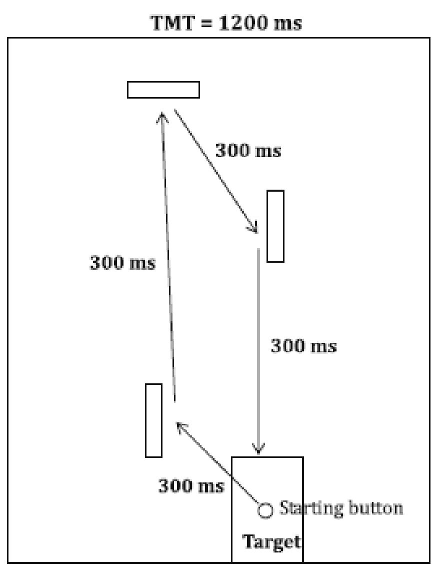

Figure 1: Experimental setup for Rohbanfard et al. (2011) in which participants knocked over the three blocks and return to the starting position.

The study involved an initial acquisition phase in which each group either performed 60 practice trials physically (PP) or observed a model performing the task (ON, OE, OM). They then performed an immediate retention and transfer test followed by a second acquisition test which involved physical practice for all groups, culminating in a 10-min and 24-hour retention/transfer test. The second acquisition phase was implemented to allow the observation groups to refine the cognitive representation of the task. As such, it integrates the sensory feedback that the participants did not receive during observation. The most important findings are that the OM and PP did not differ in retention but the OM outperformed all groups at the 24-hour transfer test with respect to absolute and relative time. This demonstrates that it may not be that one model is superior to the other but the combination of the two affords the observer with the most information, which results in better retention and transfer outcomes. As well it seems that combining observation of mixed models with physical practice allows the observer to create a more generalized representation than performing only physical practice.

Andrieux and Proteau (2013) confirmed that the combination of the two models was advantageous to learning because of the models dissimilar ability. The expert provides error free attempts which serve as a blueprint to reference the other attempts too. Their performance is characterized by very low variability from one trial to another. The novice provides errorful attempts that convey a variety of strategies through a more exploratory approach that is characterized by large variability (Figure 2). With respect to why a novice is beneficial; it has been demonstrated that trial-to-trial variability in strategy selection enhances observational learning when attempting a target pattern

(Buchanan & Dean, 2010). The variability that characterizes a novice's performance, which manifests itself in increased errors, can impact two aspects of a skill: the relative timing of a task and the absolute timing of a task.

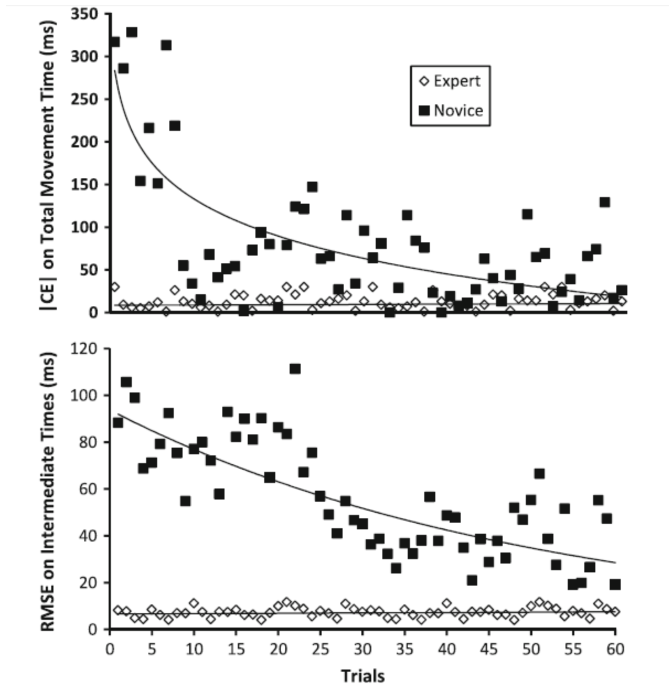

Figure 2: Absolute timing (|CE|) and relative timing (RMSE) variability that characterized the novice and expert model in Rohbanfard et al. (2011).

1.10 Information Extracted Through Observation

The next important aspect of observation that needs to be discussed is what information the observer is able to withdraw from the model. Scully and Newell (1985) suggested that observation can facilitate the acquisition of the relative motion of a movement but does not support the acquisition of the ability to achieve an absolute goal through paramatization. Therefore from an information processing perspective they theorized the schematic representation could only be built through physical practice and that the relative motion could be acquired because it was more salient. This theory has both been supported (Buchanan, Ryu, Zihlman & Wright, 2008) and refuted (Black & Wright, 2000). Both of these studies examined which aspect of a task observing a model facilitated but they did not attempt to manipulate these aspects within the model. This leads us to this dissertation's first study, which aims to determine the type of representation that can be acquired via observation. This was achieved by examining which aspects of a novice model performance variability (i.e., within relative or absolute timing) affords the observer with the most information to create an efficient representation. Specifically, we investigated whether variability within the relative timing aspect of a segmented timing task seen in a model has a greater influence on retention and transfer performance then variability within the absolute timing of the task.

1.11 Applied Kinesiology

As research within academia has progressed there has been a drastic transition, with increased collaboration between fields and a mandate to apply theoretical research. This lines up with a movement within health care known as evidence-based practice. This approach to providing the best care possible to patients has been spear headed by David Sackett (Gray & Pinson, 2003). He brought forth the idea of evidence-based medicine and was a strong contributor to its overall implementation. The goal of evidence-based practice is to provide therapeutic intervention to patients that have empirical evidence to support its use (Sackett et al, 2007). It is important that we make decisions using research and not simply going off an anecdote or gut feelings. This approach of empirical evidence driving decision making has transitioned from medicine to other health care disciplines and into other fields.

In this regard, the field of kinesiology has started to make large strides in impacting a variety of vocational fields. Biomechanical inquiries have changed how the average line worker completes their job (Abdolie-E, Damecour, Peterson, & Potvin, 2014); creating a safer and more productive employee. The field of exercise psychology impacts how we can create a lasting and meaningful change in an individual lifestyle for the better. The field of motor control and learning is flourishing within health professions education (Dubrowski & Backstein, 2004). Concepts and theories within our field lend themselves nicely to the precision tasks that are undertaken by health professions every day. Specifically within the field of medicine, surgical training is one area that could benefit greatly. Traditionally surgical trainees were trained using an apprenticeship based model (Zendejas, Brydges, Hamstra & Cook, 2013). Although this approach is still used there has been a shift towards using simulation-based training within health professions training programs (Domuracki, Wong, Olivier & Grierson, 2015). This is because using an apprenticeship based model can be very costly and create poor patient outcomes (Bridges & Diamond, 1999). Simulation-based training attempts to recreate tasks that you would encounter within your profession or daily life so that you are able to train before encountering them in the real world (Grierson et al, 2012). Simulation-based training allows the learner to engage in deliberate practice over an extended period of time while receiving feedback. This occurs in a controlled environment in which errors, which are integral in the formation of action representations, can occur without jeopardizing patient outcomes.

There are a variety of different types of surgical simulators such as box trainers, virtual reality simulators, mannequins, and plastic models (Vanderbilt et al., 2015). These simulators vary greatly in their fidelity, meaning how realistic they seem when compared to an actual surgical procedure. Although intuitively one may think a learner would benefit more from a simulator that resembles the real thing, it seems that both low and high fidelity simulator facilitate comparable improvement in performance (Norman, Dore, Grierson, 2012). Regardless of the fidelity of the simulators they provide a variety of benefits for surgical trainees and there has been a large increase in the resources allocated to integrate simulators within medical training (Reznick & MacRae, 2006). This has created a demand to find optimal ways to implement simulators within curricula to facilitate learning.

One drawback to simulators is they are temporally and spatially constrained to the simulation center where they are stored. This can pose issues with scheduling and access. One approach to extending the simulation based learning beyond the confines of brick and mortar is to implement observational learning. Given that simulation centers are typically outfitted with video recording technology, it is seen as a viable way to extend the learning associated with the practice that occurs in these spaces. This has created opportunities to demonstrate that observation of simulation practice combined with physical practice can facilitate the acquisition of clinical skills (Grierson et al, 2012). As well it has opened new lines of research where previous theories and concepts from motor control and learning can be applied to observational practice of clinical simulations to enhance the learning process. In addition, to provide the most feasible approach to implementing this type of practice within medical curriculum so that resources can be optimized. This leads us to this dissertation's second study, the purpose of which is to examine whether the use of observational learning is a feasible means to connect medical students from different distributed medical campuses. This will be supplemented with demonstrating that a combination of an expert and novice model is optimal when attempting to acquire a new manual precision skill in the clinical context.

CHAPTER II: THE EFFECT OF OBSERVING ABSOLUTE AND RELATIVE TIMING ERRORS ON THE ACQUISITION OF A SERIAL TASK

2.1 Introduction

When we perform a skill, an information processing perspective dictates that we rely on independent but integrated internal representations: the generalized motor program and the schema (Schmidt, 1975; Elliott et al., 2010). The motor program is thought to contain the invariant features of a task such as relative timing and forces associated with a coordinated sequence of impulses for a particular class of movement (Schmidt, 2003). The schema believed to be a set of rules that allow parameters such as speed and amplitude to be applied to meet the needs of changing environmental constraints. The process of skill learning involves the development of these representations via experience and practice.

Skill acquisition requires physical practice. However, there is a plethora of behavioral evidence that skill learning can occur through the observation of other individuals performing the skill (Ashford, Bennett & Davids, 2006; Hayes et al., 2013; Larssen, Ong & Hodges, 2012; Ste-Marie et al., 2012). The most prominent explanation for this phenomenon is that the processes of perception are directly linked to the processes of action within the central nervous system (Jeannerod, 2001). That is, the act of observing a skilled performance is concomitant with a covert motor simulation of that action. In this way, the CNS is provided a mechanism for developing the motor representations that underpin skills via observation. This position is supported by human brain imaging studies that have demonstrated the existence of a several neurophysiologic regions, in the primary motor cortex and pre-motor cortex, which link action processes directly with perceptual processes. (Cross et al., 2009; Higuchi et al., 2012; Buccino et al,. 2001; Dushanova and Donoghue, 2010, Rizzolatti & Craighero, 2004).

Interestingly, researchers are beginning to understand how the specific characteristics of what individuals observe impacts the way they learn a new skill. For instance, the skill level of the observed model can impact the way in which a learner's representations are formed (Heyes and Foster, 2002; Weir et al., 1990). That is, learners derive different aspects of motor representations from observing either experts or novices. Rohbanfard and Proteau (2011) explored this through a study in which they had participants learn a manual four-segment timing task in which four blocks were to be knocked down in sequence with specific absolute and relative timing goals. All participants were randomly allocated to an experimental group in which they practiced physically, observed an expert model perform the task, observed a novice model perform the task, or observed a combination of the expert and novice models for 60 trials. After which all the groups engaged in a second acquisition phase in which all groups practiced physically. Rohbanfard and Proteau (2011) measured the participants RMSE, an indication of the error performed with respect to the relative time goal. They found that after the first acquisition phase in which the observation groups had not yet engaged in physical practice, the mixed group performed equal as well the physical practice group with respect to RMSE. Additionally the mixed group performed less error than the group that observed a novice model. Furthermore, the group that observed the combination of models outperformed the physical practice and the other two observational groups on a

24-hour transfer task, in which the participants were required to attempt the 4-segment task with a new absolute timing goal.

Proteau and Rohbanford's explanation for this finding was that the models' dissimilar abilities are complementary insofar that they allow the observer to create comparisons between performances that are performed well and poorly (Andrieux & Proteau, 2013). Andrieux and Proteau (2013) further strengthened this position by conducting a similar study in which the participants either observed two expert models, two novice models, a combination of the two, or practiced the task physically. The most compelling results from this study come from the absolute constant error measure which is an indication of how accurate the participant was at achieving the absolute time goal. They found that the combined observation group outperformed the other two observation groups in the 10 min retention test. Additionally they performed as accurately as the group that practiced the task physically. In doing so they demonstrated that the effect derived from the original study was not simply attributable to the observation of two models; but that it is a function of the models' dissimilar abilities.

The novice models' performances within the Rohbanfard and Proteau (2011) and Andrieux and Proteau studies (2013) were characterized by larger margins of error and more variable attempts. This is important as increased variability has been shown to be beneficial in physical practice (Hernandez-Davo et al., 2014; Moxley, 1979; Williams & Rodney, 1978). For instance, a study conducted by Moxley (1979) had participants throw a shuttlecock to a target on the floor. The low-variable group practiced throwing the shuttlecock from the same position while the high-variability group practiced from a variety of different spots. When they were subsequently tested from a novel position, the high-variable practice group was more accurate than the low-variable group. Similarly it has been shown to be beneficial with observational learning. For example, participants who watched a model implement multiple strategies to learn a circle drawing task, who received no instruction on which strategies to implement, performed better than those that watched a model that received explicit instructions on which strategy to employ (Buchanan & Dean, 2010). The similarity between the impact of variability on the learning that results from physical and observational practice lend credence to the prominent idea that portions of the same representations that are at play during physical action are also at play during observation of that action (see Jeannerod, 2001). This covert motor activation is the foundation of theories supporting learning through observation. As such, it is expected that observing variable performances will contribute to the development of more robust motor representations.

In a segmented timing task, for example, variability can manifest itself in two forms: relative timing and absolute timing. Relative timing is the time that elapses between multiple sequential portions of a movement and as such is under the direction of generalized motor representations. Absolute timing, on the other hand, refers to a parameterization of the general representation and therefore falls under the direction of the schema representation. Both representations are thought to be acquired through physical practice but it is less clear if this is the case for observational learning.

Scully and Newell (1985) hypothesized that when a learner engages in observational learning s/he is able to extract and code the relative timing information but not the absolute motion features because relative motion is perceptually salient and absolute motion is not. This theory has empirical support, a study conducted by Buchanan, Ryu, Zihlman & Wright (2008) had participants learn a variety of different tracing tasks in which they controlled a cursor by coordinating rhythmic flexion-extension motions of the elbow and wrist. They had the participants work in dyads in which one participant physically practiced the task for several sessions while the other watched. The task required that the joints be coordinated in a particular relative pattern in order to be completed efficiently. There was no difference between the two groups with respect to the relative phase error data which is an indication of how accurate the participants performed with respect to the relative motion goal. The task also requires that each joint move with particular amplitude and only the group that physically practiced the task was able to delineate the amplitude between the two joints.

However others have demonstrated differential effects, a study by Black and Wright (2000) had participants learn a sequential key pressing task in which they had to achieve specific proportional times between each key and an absolute goal for the entire task. They too had participants work in dyads in which one individual practiced physically while the other observed. They found that at retention the two groups preformed equally well with respect to absolute timing error but the group that observed performed significantly more relative time error. Both of these studies examined which aspect of a task – absolute or relative motion - observing a model facilitated but neither attempted to manipulate these aspects within the model.

The purpose of the present study was to examine what aspect of the movement representation are formed through observation by exploring the ways in which absolute or relative timing variability contributes to an observer's development of an efficient and effective skill. To do so, we replicated the task used by Rohbanfard and Proteau (2011) and had participants engage in an observational period in which they observed one of the four models. We manipulated the variability within each model by systematically varying absolute and relative timing errors, and then had our participants attempt the task physically in post, retention, and transfer tests. We hypothesized that if individuals can only perceive relative timing information when observing a model, then those exposed to relative timing variability will perform less relative timing errors. Additionally, if parametrization of a movement can only be acquired via physical practice, then we hypothesized that the observation of absolute timing variability will not contribute to better learner performance. However, if absolute timing can be acquire through observation, then we expected a pattern of results wherein the participants that observed absolute timing variability will outperform the groups that did not.

2.2 Methods

2.2.1-Participants

Forty individuals (21 males, 19 females, mean age= 23.72 ± 2.86**)** were recruited from the McMaster University community. They were free of any upper limb injuries or neurological disorders. They had normal or corrected-to-normal vision and self-reported as right-handed. All participants provided informed consent in accordance with the guidelines set out by the McMaster Research Ethics Board and the Declaration of Helsinki (1954).

2.2.2 -Apparatus and Task

A computer monitor was fixed onto a stand that was adjusted to each participant's hip height so that it could be presented to him or her horizontally. Participants stood next to the monitor, which projected towards the ceiling as they looked down onto it. Participants were asked to perform a four-segment timing task similar to the task used by Rohbanfard & Proteau (2011). Participants began each trial with their right index finger on a home position affixed aside the monitor, after which an image of four dots appeared on the screen (Figure 1). They had to tap four dots with the index finger of their right hand in a sequential order. The first tap segment spanned 25cm, the second segment spanned 38.5cm, the third spanned 13.5cm, and the fourth spanned 24.5cm. Participants wore a simple switch trigger that was affixed to the pad of the finger. This switch worked to indicate the initiation and completion of each segment. This information was recorded via a custom script developed in E-prime 2.0 (Psychology Software Distribution Ltd, Sherrif Hutton, York).

The participants were asked to complete the task while attempting to perform the specific relative and absolute movement time goals as accurately as possible. The absolute time goal was to complete the entire task in 3000ms. The relative time goal was a 1:4:1:4 ratio in which the first segment was required to take 300ms, second segment a goal of 1200ms, the third 300ms and the fourth 1200 ms.

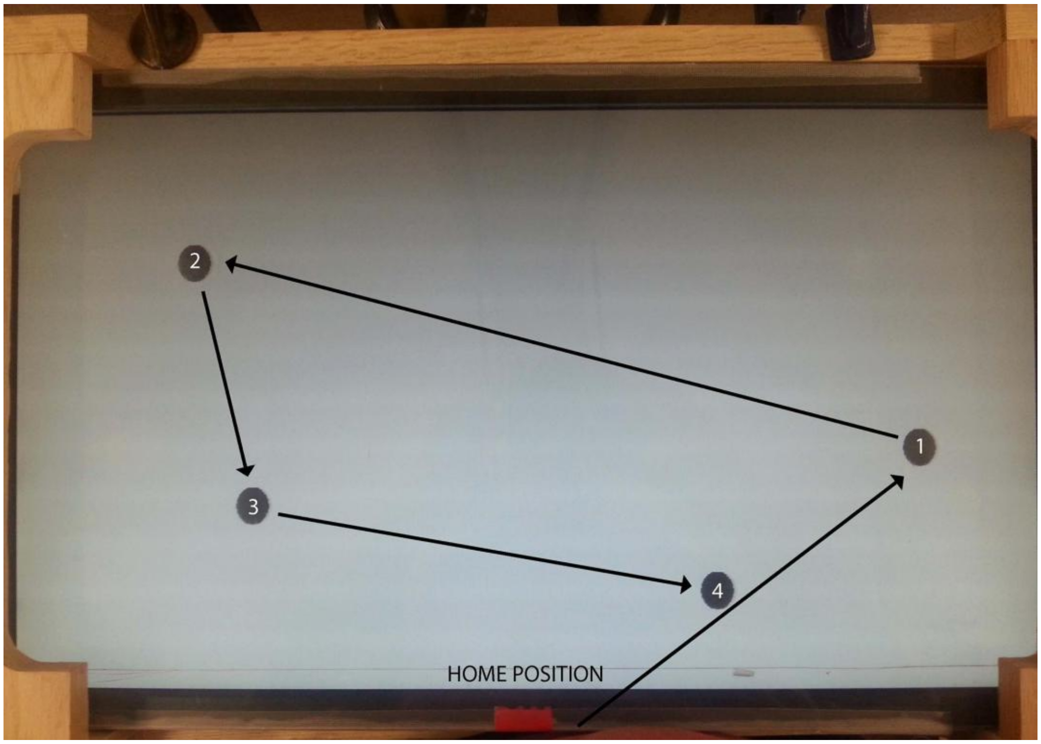

Figure 3: Diagram of the four segment timing task for Study 1

2.2.3-Experimental Design

The participants were assigned randomly to one of the four experimental groups. The first group was known as the criterion group and their model demonstrated the goal of the task with no variability. They observed the same video each time with the model executing the timing goals exactly correct. The second group was known as the absolute variability group (AT group). This group observed a model that demonstrated variable parametrization of the task while maintaining the original relative timing goal. In order to control the amount of variability around the goal, the model demonstrated attempts that were performed equally too quickly and too slowly. Specifically, there were three videos that demonstrated an error-full attempt that was too fast in which the model achieved absolute times of 2000ms, 2250 ms, and 2500ms, and there were three videos that demonstrated an error-full attempt that was too slow in which the model achieved absolute times of 3500ms, 3750ms, and 4000ms. The third group observed a model that demonstrated variability with respect to relative time while maintaining the original absolute timing goal (RT group). The model performed relative timing ratios of 1:3:3:1, 3:1:1:3, 4:3:2:1, 1:2:3:4, 2:3:4:1, 1:4:3:2, while still maintaining an absolute time goal of 3000 ms. The final group observed a model that demonstrated variability in both relative and absolute timing goals (AT + RT group). There were a total of six different videos observed by the AT + RT group: 2000 ms + 3:1:1:3, 2250 ms + 1:4:3:2, 2500 ms + 1:2:3:4, 3500 ms + 4:3:2:1, 3750ms + 2:3:4:1, and 4000 ms + 1:3:3:1. Care was taken to create videos with an equal distribution of variability around both goals. During the observation period the videos were randomized so that the same video was not seen sequentially and that every set of six videos included each different video.

2.2.4- Videos

The videos were created using a confederate model. The model performed the task 300 times with the same goal in mind as that of the participant. They received knowledge of results after each attempt. The most accurate video was taken from the set and used to create videos observed by each of the groups. Using i-movie (Apple Inc., Cupertino, CA) the attempt was segmented into four components and each segment was artificially lengthened or shortened to create each group. This insured that the variability could be controlled as much as possible allowing for equal variability above and below the goals. The resulting videos were not distinguishable as modified. This modification process has the potential to result in observed movements with velocity profiles that are not ecologically typical with respect to the movement time and distance traveled. That is, kinematic landmarks such as peak velocity and peak deceleration may occur sooner or later than they might when one actually attempts to move at the required speed. While we are conscious of this limitation of our method, we do not believe that it is confounding given that all the movements seen do not violate Fittt's law (Fitts, 1954) and each experimental group is similarly exposed to these types of movements. Therefore, there is not an advantage or disadvantage for any one group. Further, the quickest observed movement in our study is manipulated to 250ms, which constitutes more than sufficient time for the completion of a two-component aiming movement that includes discrete corrections (Elliott et al, 2001; Woodworth, 1899). Indeed, the experimentally adjusted movements in our study have characteristics that are not uncommon with respect to mean velocity of movements that have been performed by participants in previous discrete aiming research (Rohbanfard & Proteau, 2011)

2.2.5-Procedure

Each participant engaged in an acquisition phase, followed by an immediate post-test. S/he returned the following day to perform a 24 hour retention and transfer test. Before each participant began the study, s/he received instructions about the task and the absolute and relative timing goals. After becoming familiar with the task and it goals the participant was asked to perform a pre-test in which s/he attempted the task physically 10 times with no feedback. S/he then engaged in the acquisition phase of the study in which s/he observed 60 physical attempts of the task being performed by her/his group's respective model. After each attempt s/he received knowledge of results of both the relative and absolute times achieved by the model. S/he was then asked to physically perform the task 10 times as part of the immediate post-test. S/he then returned 24 hours later to perform the retention and transfer test. S/he had to once again complete the task 10 times with the same original goals for the retention test. S/he then received new goals for the two transfer tests. The relative time transfer test had the participants perform a new relative time goal while still performing the same absolute goal. The new goal was a relative time goal 3:1:2:4 for an absolute time of 3000 ms. While the absolute time transfer had the participant perform a new absolute time goal while maintaining the same relative time goal. The new goal was an absolute time of 4500 ms and a relative time goal of 1:4:1:4. The transfer tests were counterbalanced across participants.

2.2.6- Dependant Measures

There were two main dependent variables measured: relative timing error and absolute timing error. Relative timing error provides an indication on the efficiency of the generalized motor program, while the absolute timing error provides an indication of the participant's ability to paramatize the movement. In order to determine the relative timing error, we employed AE proportional equation:

$$\textbf{Relative timing error} = |R_1 - .1| + |R_2 - .4| + |R_3 - .1| + |R_4 - .4|$$

Where, R_1 is the proportion of the whole movement time taken up by the first segment, R_2 is the proportion of the whole movement time taken up by the second segment etc. Badets, Blandin & Shea (2006).

In order to determine the absolute timing error, we employed the following equation:

$$\textbf{Absolute timing error} = |\text{actual movement time} - \text{total criterion time}|$$

2.2.7- Data Analysis

Both relative and absolute timing error were analysed at all tests. A four Group (Criterion, AT, RT & AT+RT) by three Test (Pre-Test, Post-Test, Retention Test) repeated measures analysis of variance (ANOVA) was completed. Independent one-way ANOVAs with Group as the only factor were completed for both transfer tests. Effects significant at any alpha set a $p < 0.05$ were further analysed using Tukey's Honest Significant Difference post hoc methodology. Assumptions for all statistical analysis were tested and were met unless otherwise stated.

<u>2.3 Results</u>

2.3.1- Absolute Timing Error

The four group by three test ANOVA of absolute timing error data was not normal. We transformed the data by using an exponential transformation, specifically we completed a $x^{0.25}$ transformation. A transformation was necessary because the data was not normally distributed but had a positive skew. This transformation is similar to a logarithmic or reciprocal transformation, which can be used to reduce a right skew. Each data point was raised to the power of 0.25. All assumptions were met using this transformation. The four group by three test ANOVA of absolute timing error indicated a main effect of test ($F(2,72)= 12.766$; $p< 0.001$) . Post-hoc analysis showed that all the groups did significantly better at post (grand mean = 4.60 ± 0.12) and retention (grand mean = 4.6 ± 0.15) test as compared to the pretest (grand mean = 5.33 ± 0.13) errors. There were no higher order interactions. The one-way ANOVA's for both the absolute timing transfer and relative timing transfer showed no significant differences.

2.3.2- Relative Timing Error

The four group by three test ANOVA of relative timing error indicated a main effect of test ($F(2 ,72)= 90.539$; $p< 0.001$) and of group ($F(3 ,36)= 3.293$; $p< 0.031$). As well there was a significant group by test interaction $F(6, 72)= 3.498$; $p= 0.004$) (Figure 4). Post-hoc analysis indicated no difference between groups at pre-test (grand mean = 34.09 ± 1.87). At post-test we see that the AT group performs significantly more errors than the other three groups. This difference is also maintained at retention. As well at post-test the AT + RT group performed significantly more errors than the criterion and RT group. At retention the AT+RT group is performing significantly more errors than the criterion group but not the RT group.

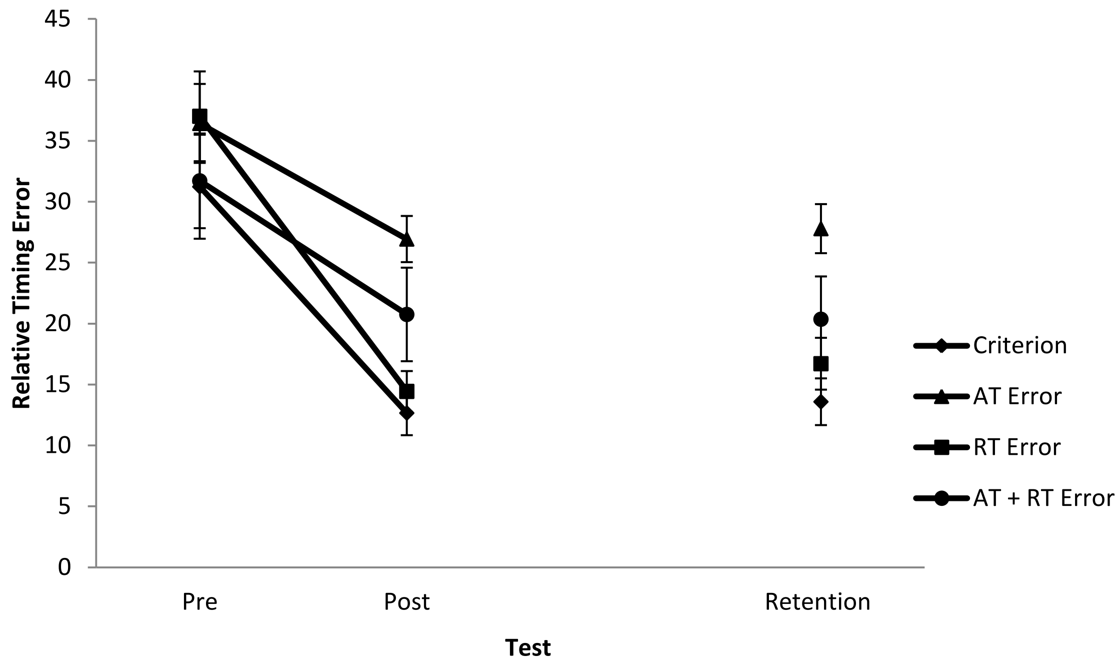

Figure 4: Four group by three test mixed ANOVA for relative timing error for Study 1

The one-way ANOVA for the AT transfer had no significant differences. The one-way ANOVA for the RT transfer did show a significant difference between groups (F(3 ,36)=3.75;p=0.020). Post-hoc analysis revealed the criterion group performed significantly better than the AT and AT+RT group. As well the RT group performed significantly better than the AT group (Figure 5).

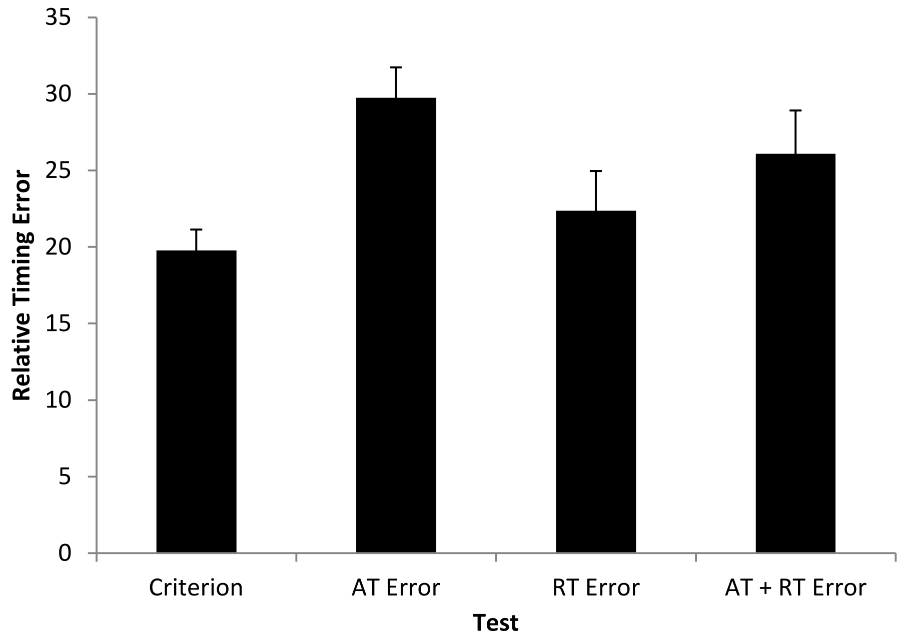

Figure 5: The means (SE) of relative timing error for RT transfer for Study 1

2.4 Discussion

In this study we set out to determine the representation characteristics that a learner acquires when observing variable motor skill performances. Previous research points out that novice models are characterized by errors that are manifested in variable attempts are beneficial for skill learning (Rohbanfard & Proteau, 2011; Andrieux & Proteau, 2013; Blandin & Proteau, 2000). Accordingly, we set out to understand what type of variability is most important to a learner when observing a model perform a task. We did this by creating videos of models performing a four segment timing task in which we manipulated and controlled relative and absolute timing variability systematically.

Our first hypothesis was that relative timing information contributes to observational learning, and therefore we expected that those groups that viewed variable relative timing attempts would perform fewer errors. Our analysis revealed that the AT group that was not exposed to any relative timing variability performed the worst, and, the RT group, that was exposed to relative timing errors exclusively performed the best with respect to relative timing errors. These findings suggest that the relative timing variability in observation is allowing for a stronger representation to be formed. This position is further supported insofar that the AT + RT group, which was exposed to variability in both absolute and relative timing, also performs better than the AT group.

Interestingly, the group that performed the best with respect to relative timing errors in the retention and transfer test was the criterion group, which was unexpected. Seemingly, observing the task performed correctly with no variability contributed to the strongest representations formed. The criterion manipulation is essentially a surrogate for the observation of an expert model, which has been shown to be an adequate for acquiring motor skills (Buchanan & Dean, 2014). However this group does not perform significantly better than the RT group suggesting that although the learners are getting different information from each model it still affords them the opportunity to perform the goal accurately.

Another important result that is pertinent to the first hypotheses is that the transfer test results provide an indication how well the participants were able to generalize their representation to create a novel relative timing goal. During the RT transfer, participants were asked to produce a novel relative pattern that they had not seen or performed previously. The results show that the RT group performed this challenge significantly better than the AT group. This leads us to believe that the observed variability allowed them to for a representation that was more generalizable to new relative timing constraints. Again, the more surprising result was the criterion group outperformed the two groups that were exposed to absolute timing variability. Thus, the results suggest that learners are able to extract relative motion information through observation to create an efficient and generalizable motor program. However, given the results associated with the criterion group it appears that viewing no relative timing variability is equally beneficial to the development of these representations.

Our second hypothesis was that absolute timing information does not contribute to observational learning; therefore we expected the results associated with errors in absolute timing would demonstrate that all groups performed equally well. The reasoning for this hypothesis is based on the idea that parameterization of a movement is not salient to observers (Scully & Newell ,1985). The absolute timing error measures derived from this study suggests that there were not differences in one's learning to parameterize movements based on their assigned observational models. That is, although some participants were exposed to variability with respect to the absolute time goal it did not contribute to being able to produce more accurate physical absolute timing goals. Although there was an overall improvement, we believed that if absolute timing information contributed to observational learning then viewing variable attempts would provide an advantage, similar to the way engagement in variable physical practice enhances learning (Landing, Hebert & Fairweather, 1993). However, this was not the case.

Taken together, this study has leads us to believe that individuals that engage in observational learning are able to extract and code information related to the construction of generalized motor programs. However the acquisition of a schema through observation is less proficient, and that the ability to parameterize movements likely necessitates physical practice. With respect to what type of variability is most important when observing a model, the suggestion is that variability in the relative aspects of a skill is most important to observational learning. Finally, the study demonstrates that for a precision serial task, an expert model that demonstrates little or no variability may be equally as beneficial as viewing a highly variable model. However, regardless if the learner viewed variability with respect to relative timing, absolute timing, or viewed no variability whatsoever, it is critically important to point out that learning was possible.

CHAPTER III: THE IMPACT OF OBSERVING MODELS OF DIFFERENT SKILL LEVELS ON CLINCAL SKILL LEARNING

3.1 Introduction

The previous study focused on advancing theoretical constructs around observational practice, this type of research endeavor is classified as an experimental research study. The importance of experimental research cannot be stressed as it drives changes within a real world setting. However, it is also imperative to apply these findings in various ecological contexts. The following study attempts to apply ideas and theories that have been demonstrated within a highly controlled environment to an applied setting. With the hope that these results can create changes within an ecological setting (Calder, Phillips, & Tybout, 1981). Specifically the following study will apply theories from motor control and learning to medical education. The acquisition of precision manual skills is a critical part of clinical learning within the field of medicine and a large portion of this training now occurs outside operating rooms and wards using simulation-based training (Reznick & MacRae, 2006). Specifically, there is an increase in the use of simulation within surgical training; largely because it affords learners a controlled environment in which they can engage in deliberate practice, receive constructive feedback, explore different strategies, and make errors in practice without jeopardizing patient safety (Domuracki, Wong, Olivieri & Grierson, 2015; Kneebone, 2003). However, simulation centers are resource dependent and ultimately pose scheduling, opportunity, and availability constraints on trainees.

One way that simulation-based learning may be extended beyond the physical confines of the simulation centre is through video-based observational practice. The learning of a new motor task involves the formation of action representations within our central nervous system (Elliott, Grierson, Hayes & Lyons, 2011; Schmidt, 1975). These representations encode important force and timing information, which serve as the underlying program for the impulses that constitute the movement. This information is refined through physical practice of the skill (Schmidt, 1975). Interestingly, new research has revealed that observing an individual perform a skill, also allows the observer to extract key spatial and temporal information that can be used to bolster a developing action representation (Mattar & Grible, 2005; Ashford, Bennett & Davids, 2006; Hayes et al., 2013;). One empirically-supported explanation for this phenomenon is a group of "mirror" neurons that activate both when a goal-oriented task is performed and when it is observed (Pellegrino et al., 1992). That is the observation of an action is concomitant with a covert version of the same neural activation that occurs when one performs that action (Cross et al., 2009; Higuchi et al., 2012). In this way the observation of a skill involves a form of sub-neuronal threshold motor simulation (Maslovat, Chua & Hodges, 2013).

Importantly, the study of observational learning has revealed that the characteristics of the observed model have a significant impact on the degree and nature of the skill learning that results (Weir & Leavitt, 1990). For example, it has been shown that both experts (Heyes and Foster, 2002) and novices (Buchanan and Dean, 2010) can be effective models that support observation-based learning. The idea is that the type of model influences what information is presented to the observer and, consequently, impacts the way the action representation is formed. Rohbanfard and Proteau (2011) examined this phenomenon more closely, and found that observing a combination of an expert and novice model was optimal for learning a new motor task. The two types of models combined together allowed the participants to create a more robust action representation (Andrieux & Proteau, 2013).

Presumably, a combination of expert and novice demonstrations supports skill learning because of the models' dissimilar abilities. Our neuromuscular system is inherently noisy, and this noise manifests itself as spatial variability in the outcomes of our movements (Meyer et al., 1988; Schmidt, 1979). As such, the process of acquiring efficient motor skill precision involves that learners develop strategies to manage the potential consequences associated with errors that result from this variability (Elliott et al., 2010). While expert demonstrations provide learners with error free attempts that serve as a foundational blue print for the skilled movement, viewing novices exposes learners to the variety of strategies a performer may explore in order to minimize this variability.

The demand for medicine has no geographic boundaries and, as such, medical practitioners and trainees, regardless of institutional affiliation, are often situated in different communities that are separated by large distances. This arrangement, while necessary to meet the health care needs of a distributed population, introduces a number of challenges to medical educators. One of which is to ensure that the learners, regardless of their geographical location, receive equivalent education opportunities (Myhre et al., 2014). This can be difficult at times if the appropriate infrastructure is not in place to support the learners. Similarly some diseases may be more prevalent in certain areas, which can impact the focus of the curriculum. Another challenge is the number of assessors available in certain medical teaching environments. At a community health clinic teaching site, there may be only one individual that is qualified to assess student progress and this individual may be biased because they have developed a relationship with the learner, exhibiting a halo effect, which can in turn compromise the reliability and validity of the clinical assessment (Streiner, Norman & Cairney, 2015). In this study, we explore the way in which observational practice, and the covert motor activation that underpins it, can have utility to effective medical learning across a distributed medical education network. Our primary purpose is to extend simulation-based learning beyond the confines of the simulation centre and the single institutional campus by connecting learners using an online-mediated learning environment. This study demonstrates that observation is a feasible and efficient method of enhancing clinical skills training. In addition, this work also will look to generate empirical evidence that supports the hypothesis that a combination of expert and novice models is optimal for observation-based skill learning. In doing so, the data will be interpreted for its relevance to the organization of medical education activities.

Specifically, medical students from McMaster's distributed medical campuses were recruited to participate in an observational practice study in which they were challenged to learn the elliptical excision (EE) skill. The EE is a common surgical task that involves sizing, and outlining, incising, undermining, and excising, and closing the ellipse with three sutures. The participants used a simple interrupted suture to close the ellipse. The participants engaged in observational learning as part of 1 of 3 groups: a group that observed novices performing the task, another group that observed experts performing the task, and a 3rd group that observed both novices and experts performing the task. Our first hypothesis is that all students will improve from test to test. Our second hypothesis is that those students in the group who observed both novice and expert models will perform the best.

3.2 Methods

3.2.1- Participants

Twenty individuals (6 males, 14 females, mean age = 23.47±0.51 years) were recruited from the Michael G. DeGroote School of Medicine at McMaster University network of distributed campuses: the Niagara Regional Campus in St. Catharine's, Ontario (n=9); the Kitchener-Waterloo Regional Campus in Kitchener, Ontario (n=8), and the Hamilton Regional Campus in Hamilton, Ontario (n = 3).

One additional undergrad student with aspirations to pursue medicine also participated in the study (female, age = 22 years, Hamilton, Ontario). All participants had no experience performing an elliptical excision and very little experience suturing (3.4 ± 2.36 hrs total practice**).** All participants provided informed consent in accordance with the guidelines set out by the Hamilton Integrated Research Ethics Board and the Declaration of Helsinki (1954).

3.2.2 -Protocol

The protocol was divided into 5 phases: warm-up, pre-test, acquisition, post-test and retention (Figure 6).

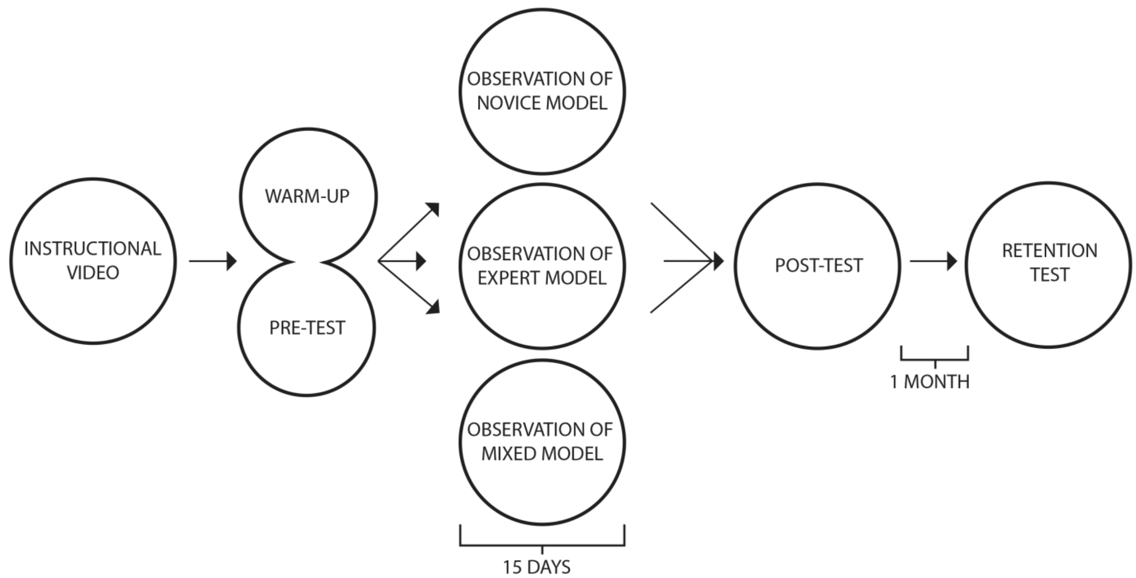

Figure 6: Schematic of protocol for Study 2

3.2.3- Warm-up

In the pre-test phase, participants began by observing a standard and error-free instructional video that demonstrated the correct technique to performing the EE, and a simple interrupted suture. They then read a set of written instruction that outlined the procedure in detail. They were also given the opportunity to view both the checklist and global rating scale that would be used to rate their performance. They repeated this until they had viewed the video and read the instructions three times. They were then given the opportunity to perform the procedure on a skin pad (Professional Skin Pad Mk 2 - Light, Limbs & Things, Canada) as a warm up. All the participants wore latex gloves. They were provided with no augmented feedback regarding the performance or results of their warm-up attempt. They then viewed the video and read the instructions one more time.

3.2.4- Pre-test

Participants then performed the pre-test, which involved a video-recorded attempt of the EE on a skin pad. All the pre-test attempts were recorded so that they could be rated by a group of surgical experts, and used within the acquisition protocol.

3.2.5-Acquisition phase

The next portion of the study involved the acquisition phase. The participants were randomly allocated to one of three experimental groups using a random number generator. Separate one-way analyses of variance (ANOVA) of the participants' checklist and GRS pre-test performances were completed to ensure group equivalence before the intervention period. Each group was asked to observe, and assess a performance of an EE every other day for a total of 15 days so that each group observed a total of 8 videos.

The groups were defined by their observation of performances that either contained or did not contain performance errors. Group E (n=5) viewed an expert demonstration every other day, Group N (n=8) viewed a novice demonstration every other day, and Group NE (n=8) viewed interleaved expert and novice demonstrations over the acquisition phase. All the groups were counterbalanced with respect to the order of the videos. Half of the participants who were in Group N viewed the videos in one order, and then half were viewed them in the reverse order.

The expert videos were created by filming a general surgeon who performed the EE using the same tools and simulation apparatus as the participants. A total of eight videos were created, one per viewing day within the protocol. All the videos were rated to ensure each video was an error free example. The mean checklist score for the expert videos was 24.88 ± 0.35 out of a possible 25 and the mean global rating score was

4.95±0.14 out of a possible 5. The novice videos were chosen from the pool of pre-tests performed by the participants. The novice videos that were used had to have achieved a score between 30-70 % on both the checklist, and global rating scale that were used to rate the videos. From the pool of pre-tests that met this criteria the videos used within the group were randomly selected. The mean checklist score for the novice videos was 13.88±3.04 and the mean score for the global rating score was 2.175±0.33. No participants viewed their own videos. The videos were observed via the OPEN online mediated learning system.

The OPEN system is an internet-mediated environment in which learners can access video based observational technology that integrates social networking and game-play mechanics. It affords learners the opportunity to access all the videos associated with the acquisition phase. The video are presented alongside the rating scales, allowing the users to observe the videos while rating the performance of that particular model. Game-play mechanics can be manipulated using the feedback the learners receive on their ability to rate the videos.

In addition to observing a video every other day, the participants were also expected to rate the videos using a modified Objective Structured Assessment of Technical Skills (OSATS) checklist and global rating scale (Appendix A), each of which has been shown to be reliable and valid, were used to rate all physical attempts (Alam et al., 2014). The checklist measure captures the procedural portion of the task, and is associated with the cognitive demands of the movement. The global rating scale is a subjective appraisal of the precision aspect of the skill such as fluidity, efficiency of motion, and tissue handling.

3.2.6- Post-test and Retention

After the 15 day acquisition phase (i.e., on day 16), the participants returned to perform a post-test. Each participant performed another physical attempt of the EE on a skin pad, which was again filmed and rated. Finally, they returned one month later (i.e., on day 45) to perform a retention test that followed the same protocol as the pre-test and post-test.

3.2.7- Dependant Measures and Rating

All performances were rated by senior surgical residents that are regularly involved in the education and assessment of the EE skill. The videos of the performances were also accessible to the raters on the OPEN system. Each video was rated by three different residents using the OSATS checklist and Global Rating Scale. A minimum of two raters had to rate the item in the same manner for it to be documented. If all three raters disagreed on an item, which could only occur on a global rating scale, a fourth rater was used to break the deadlock. The dependent measures were the total checklist score and the average global rating score.

The rating occurred in two phases; the first phase involved rating the pre-test attempts, while the second phase involved rating the post-test and retention. All raters were blinded to group assignment, test, and participant. Any dependent measure scores that were greater than 2.5 standard deviation units from the mean within a particular test were considered outliers and removed from the analysis.

3.2.8- Analysis

Inter-rater reliability was established using interclass correlation. A one-way ANOVA of the pre-test checklist and global rating scores was completed. In addition the global rating score and checklist scores were compared in an independent three-group (Expert, Novice, Expert/Novice) by three test (pre-test, post-test, and retention) ANOVA. Effects significant at any alpha set a $p < 0.05$ were further analyzed using Tukey's Honest Significant Difference post hoc methodology.

3.3 Results

3.3.1 - Inter-rater reliability

Interclass correlation between the raters was found to be strong for checklist ($r = 0.893$; $p<0.001$) and for the global rating score ($r = 0.800$; $p<0.001$) (Streiner, Norman, & Cairney, 2015).

3.3.2- Pre-test Analyses

The analysis of the Pre-test checklist measures revealed no significant difference between groups at pre-test ($F(2,18) = 2.721$; $p=0.093$). Similarly the analysis of Pre-test global rating scores revealed no significant difference between groups at pre-test ($F(2,18) = .022$; $p=0.254$).

3.3.3- Checklist Scores

The analysis of the total checklist score measures revealed a significant main effect of test (F (2,36)= 19.635; p< 0.001). Post-hoc comparison of this effect indicated a significant difference between the pre-test scores (M=18.639±.948), and the retention test scores (M=23±.498). As well as post-test scores (M=20.047±.8), and retention test scores. This effect was superseded by a significant Group by Test interaction (F(4,36)= 19.976; p= 0.028) (Figure 7). Contrary to our pre-intervention analysis of the pre-test scores, post-hoc comparison of the interaction indicated that the Expert group scored significantly lower at the pre-test as compared to the other two groups. At post-test and retention test there was no significant difference between groups. As well, the Expert group significantly improved from post-test to retention, while the other two groups did not.

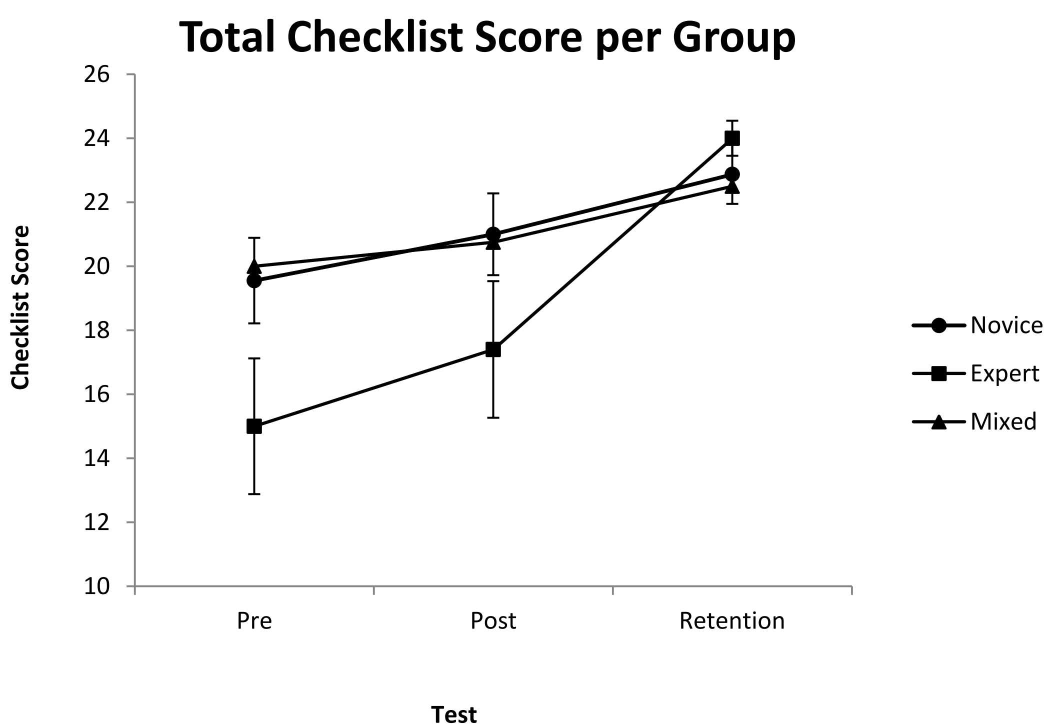

Figure 7: Checklist assessment data for each experimental group (Expert, Novice, & Mixed) plotted as a function of tests (Pre, Post, & Retention) for Study 2

3.3.4-Global Rating Scores

The analysis of global rating scores dependent measure revealed a significant main effect of test ($F(2,36)=29.582$; $p< 0.001$)(Figure 8). Post-hoc comparison of this effect indicated a significant improvement in global rating scores from pre-test to post-test and from post-test to retention test.

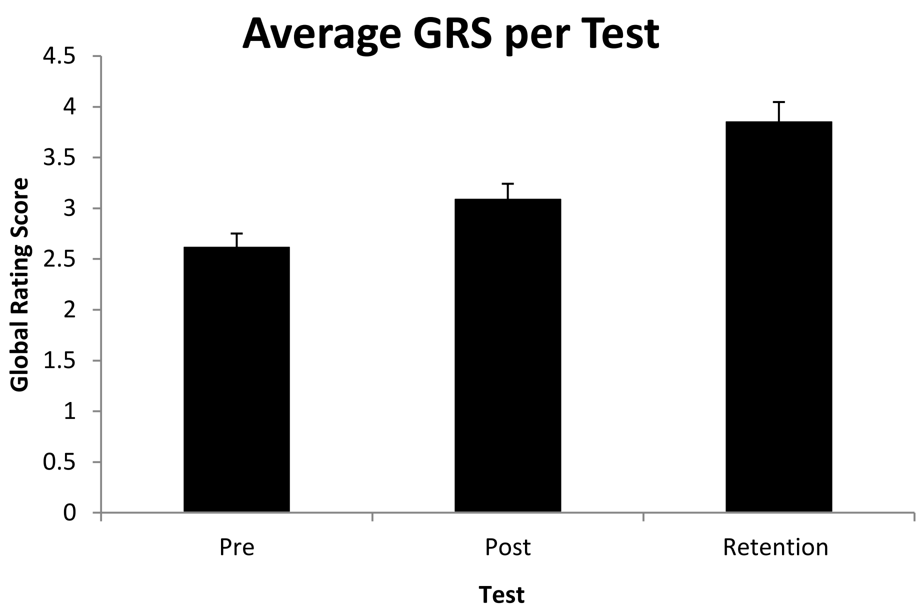

Figure 8: Average global rating scale data plotted as a function of tests (Pre, Post, & Retention) for Study 2

3.4 Discussion

This study aimed to demonstrate that video-based observational practice can support clinical skill learning outside of the simulation centre, while also investigating the effect that a combination of expert and novice model demonstrations has on the acquisition of a precision clinical skill. As such, our first hypothesis was that observational practice would support skill learning such that all participants would improve over the observational intervention period. Our second hypothesis was that the individuals that observed a combination of expert and novice demonstrations would outperform groups that observed only expert or novice demonstrations.

In regards to the first hypothesis, both the checklist and global rating measures demonstrate that all three groups improved over time. That all participants outperform their pre-test performances on both measures at retention test indicate that the observational learning effect is robust, regardless of the model viewed.

With respect to our second hypothesis, examination of the interaction that results from the checklist measure analysis reveals differences between the groups at pre-test. While these between-group differences were not evident statistically at the time of group allocation, it is clear that these differences are most likely driving the interaction. The expert group begins at pre-test by scoring significantly lower than the other two observational groups. However, at post-test and retention, the difference is no longer apparent, and all three groups are performing equally well. Although all three groups perform equally at the conclusion of the experiment, we cannot deny that the expert group improves significantly more from post-test to retention than do the other two groups. As such, it may be that for a new learner of this type of task, observation of an expert model may facilitate larger improvements as opposed to observation of a combination of expert and novice models (*cf.* Rohbanfard & Proteau, 2011; Andrieux & Proteau, 2013).

Both measures demonstrated that all participants, irrespective of the model they observed improved at each test point. Additionally, the groups improved from post-test to retention without engaging in any additional practice. We speculate that this may suggest that participants experienced some offline performance gains (Diekelmann & Born, 2007). Offline gains are gains in motor proficiency that occur after a 'sleep' period in which the representation consolidation is enhanced, making it more robust, less vulnerable to forgetting, and can lead to better performance outcomes (Wright, Rhee & Vaculin, 2010). These gains are seen most often in procedural tasks, such as the EE, and the consolidation seems to allow the more problematic areas to improve, creating one unified representation (Walker & Stickgold, 2006).

Importantly, this study has demonstrated that in certain applied settings differential observational models may contribute similarly to motor skill learning. With respect to medical education, these findings suggest that educators may have some flexibility when designing curricula. Observational learning can be used in a number of ways. For instance, if an educator has a big class of novices, then they can be partnered off into dyads to practice and watch each other practice, simultaneously (see Wulf, Shea, & Lewthwaite, 2010 for a review of dyad learning in medical education). If an educator has a group of mixed-level learners, then they can also partner into groups that include different levels of skills. Additionally, in the most traditional sense, educators can also feel confident in the classic observational model in which learners observe expert faculty performances.

Most interestingly, we see that although certain participants may be located in different geographical areas, learners improved overall, demonstrating that observation can be used as a tool to connect learner creating equivalent education. The use of video-based observation allows the learners to be exposed to a variety of EE performances that they may not have experienced otherwise. This is an important benefit of using an online-mediated learning environment in that it affords the learners an opportunity to gain exposure to particular conditions or diseases that they may not experience within their educational settings. Secondly, it is noteworthy that the OPEN system allowed raters to access a learner’s performance remotely, through the use of video-based observation. This suggests that there is potential for clinical skill assessments to involve more raters, and to be conducted by raters that do not interact with the learners on regular basis, reducing the possible scoring bias.

CHAPTER IV: GENERAL DISCUSSION (Study 1 & 2)

4.1 General Discussion

This chapter investigates the findings and implications of the two studies as they relate to each other. The purpose of the first study was to examine what memorial representations are acquired via observation. This was done by exploring the factors about a novice – that is what types of errors and variable attempts - impact how a learner's action representations are formed when they observe performances of a motor skill. The second study examined whether a combination of an expert and novice model was ideal when engaging in observational practice of a new clinical skill. As such, we discuss the impact of errors and variability on acquiring a new task and whether they are necessary for new learners. We also explore the value of expert and novice models when a learner is first attempting a new skill. The chapter will discuss some of the limitations within the studies, consider the challenges in replicating experimental data in ecological contexts, and conclude with comments on future directions and remaining gaps in the literature.

4.2 Impact of Variability

When we begin to acquire a skill, we create an action representation, which is strengthened as we practice (Schmidt, 1975). Schmidt believed that as you increased the variability of practice within a schema class, the representation would be stronger and the learner would be more accurate at the task. Empirical support exists that demonstrates that those that engage in variable practice are more accurate when attempting a novel goal (Moxley, 1979; Willimans & Rodney, 1979). This variability of practice is generally discussed with respect to a learner's ability to scale a movement. It is thought that if a learner is exposed to different scaling experiences they will be more inclined to extrapolate to meet a new outcome goal. However when we engage in observational learning, it is hypothesized that variability in the form of errors is more important for constructing the generalized motor program (Scully & Newell, 1985); and not the schema.

Although observation is said to engage the motor system directly, it may simply be on a sub-threshold level (Maslovat, Chua & Hodjes, 2013). The power of observation may come from strategic planning of action representations. Therefore learners who engage in observational practice attend to aspects related to the general motor program, because they are the more salient aspect of the movement, which allows them to create strategies to avoid errors when physically performing the task. The results from Study 1 support this notion. When individuals were tested on a new relative timing goal those that were exposed to variability with respect to the relative time outperformed those that did not. Additionally, we saw no difference with respect to the performance on a novel absolute time, which demonstrates that even though certain participants were exposed to variable scaling it did not manifest itself in a more efficient schema. This may be due to that fact that physical practice is necessary to strengthen the schema and requires sensory feedback to strengthen the schema (Rohbanfard & Proteau, 2011).

If we reflect upon these results with respect to the second study, then it is essential to point that we did not manipulate the observed errors as a function of the relative motor components or their parameterization. As such, given that we see that there are no differences in performance between the groups that viewed errors and those that did not, our position is that the variability that was viewed by the participants was more related to strategic relative timing associated with the novice attempts at the elliptical excision task.

4.3 Expert vs. Novice model

As previously outlined it has been demonstrated that a combination of expert and novice models has been shown to be optimal when acquiring a new motor task through observation (Rohbanfard & Proteau, 2011; Andrieux & Proteau, 2013). The results from Study 2 demonstrate a different trend - that there seems to be a robust effect when acquiring a new clinical skill regardless of the model viewed. An interesting effect within the interaction is that from post-test to retention we see that the expert group improves significantly, while the other two groups do not. Although we believe that this is an artifact of pre-intervention group differences, we must acknowledge that viewing an expert model may in fact have contributed to the creation of a stronger representation. It has been shown in some instances that an expert model allows for better performance than viewing a novice model (Blandin, Lhuisset & Proteau, 1999). Other studies have demonstrated no difference and it may be due to the types of tasks employed in these studies. It is thought that when the task is less complex the type of model doesn't impact performance, but when the task is more complex an expert model may be more suitable (Rohbanfard & Proteau, 2011). In this way, our results may reflect the complexity of the elliptical excision skill.

The first study lends support to the utility of an expert model through the interaction in which the expert group improved to a greater degree than the other two groups. The criterion group demonstrations from the first study are analogous to the observation of an expert model that demonstrates no errors or minimal variability. The results show that the criterion group performed the least amount of relative timing error, significantly less than the AT group and AT + RT group at both post-test and retention. Therefore we can draw a conclusion that observing an expert model was superior to observing a novice model, as the AT + RT group demonstrations are analogous to those produced by a truly novice model. Another supporting factor to this claim is that the criterion group was able to generalize their motor program to create a new relative time goal. This is a true marker of learning and is an interesting finding as the participants in this group did not view any other relative timing patterns.

Rohbanfard and Proteau (2011) discuss studies in which the participants had to learn an absolute time goal (Blandin & Proteau, 2000) as compared to an absolute time goal and relative time goal. The studies that have participants learn both goals (Blandin, Lhuisset, & Proteau, 1999), regardless if the task is the same, demonstrate a larger benefit of an expert model. This provides further support that the task within Study 1 may have been more complex than Study 2 and this may have led to the expert model demonstrating a larger benefit.

Overall the results from both studies indicate that when new learners engage in observational practice that novice demonstrations *can* be beneficial but expert demonstrations are *always* beneficial. Presumably, the expert demonstration allows the learner to view an error free attempt, which they can later attempt to emulate physically. It may be that new learners require a foundation, which can be built from observing an expert model, before they can benefit from viewing errors and creating strategies to minimize their own inherent variability.

4.4 Reflections of Constraints-based Theorem

This thesis took an information processing approach when examining our findings. However they can also be discussed from a constraints-based perspective. Through physical experience with a task individuals are thought to eventually coordinate their degrees of freedom into an appropriate manner to efficiently achieve a goal. It is thought that as we are attempting a skill we are looking for attractor states which are stable states of organization within a movement (Anson, Elliot & Davids). An example of when individuals are drawn to an attractor state is when we increase our walking pace to the point where we transition into a run. When you are walking you are able to coordinate all your degrees of freedom in manner that is comfortable and has little variability in the way the movement elapses. However if you are to increase you speed for example on a treadmill there will be a point where you're walking state is very chaotic and variable, which will cause you to switch into a run which is an attractor state with less variability.

When we examine the results from study 1 we found that the group that viewed variability with respect to the relative time goal performed equally well as the criterion group. Additionally the criterion group outperformed the AT and AT+RT groups on the relative timing transfer test, demonstrating they were more skilled at the serial task with respect to the relative time goal. One similarity that the criterion group and the RT group have is they both demonstrated no variability with respect to the absolute time goal. While the AT and AT+RT groups both demonstrated variability with respect to the absolute time goal. Therefore the non variable absolute timing within the groups may have acted as an attractor state. This allowed them to learn how to coordinate their degrees of freedom to achieve the relative time goal.

The results from study 2 demonstrated that those that viewed an expert model had a significant improvement from post test to retention, while the other two groups did not with respect to the checklist measure. The expert model demonstrated the movement accurately while exhibiting little variability. Similar to the running example, the expert model is an attractor state because the expert model demonstrates a stable non variable manner to coordinate the learner's degrees of freedom. Therefore the results we found may due to the fact that the participants who observed less variability were attracted to that state and therefore were able to more accurately coordinate their limbs to achieve the goal.

4.5 Experimental vs. Ecological Context

Both experimental and ecological research play an important role within academia and society. Generally, experimental research precedes ecological research by creating a foundation of theories and laws that can later be applied to real world situations. For example, it was necessary to create a foundation of how the human body functions beginning with the components and intricacies of a cell before researchers could create interventions and drugs to combat diseases that plagued humans (Black, 1997). Although at times ecological research may come first out of necessity, for example using non-conventional approaches to treat patients when all other options have been exhausted, however then individuals will work backwards to understand the mechanisms.

This brings us to one of the main differences between conducting research in an experimental setting versus an ecological setting. The differences lies within the goals of the scientist and how they hope their results will be interpreted. The goal of experimental or theoretical research is to apply the effects within their studies to general theoretical understanding, while ecological experiments are concerned with the effects that are observed within that particular context (Calder, Phillips, & Tybout, 1981). Although there is a large overlap between the goals of both approaches, the way with which the tasks and measurement tools are viewed demonstrate the divergence of the two approaches. The tasks employed within experimental research are generally associated with objective and sensitive measures. This is because the tasks are simply a means to demonstrate a theoretical construct, which they believe is universal. In essence the nature of task is of little concern, unless the theory revolves around task characteristics. On the contrary ecological research is quite concerned with the task and the context in which the study is undertaken. The goal of applied research is to demonstrate that the theory that was developed using laboratory tasks, with which extreme care is taken to minimize all extenuating variables, holds up in an ecological setting. This can pose some issues as many tasks that are undertaken within a real world setting are not associated with objective measures. Within the context of medical education subjective tools such as checklists are used to indicate how well individuals performed a particular clinical skill. These measures may not be as sensitive as those employed within a laboratory setting.

These differences between the two contexts need to be taken into consideration when interpreting results. Within our studies the findings from Study 2 are directly counter to the inspirational studies conducted by Proteau and colleagues (Rohbanfard & Proteau, 2011; Andrieux & Proteau, 2013) In this regard, it is noteworthy that Proteau used a direct measures of timing accuracy, which is a considerably more sensitive form of measurement than either subjective checklist and global rating scales. Additionally, the task learned in this study was more continuous in nature, spanning a much longer time period than the serial timing task seen in the Proteau study. The tasks also contained different components, the Proteau studies had movements that were gross in nature, where the participants hit over blocks with their entire hand. While the EE involved fine motor movements that contained a larger cognitive component. This may have also led to different results as task characteristics can impact how learners react to observational learning (Ashford, Bennet & Davids, 2006).

4.6 Limitations and Future Directions

In Study 1, the participants had two goals they were attempting to achieve, an absolute timing goal and a relative timing goal. Care was taken when providing instructions to the participants to emphasize that they were attempting to achieve both goals as accurately as possible. However one limitation to the study is we do not know how the participants prioritized the two goals. Individuals have a limited attentional capacity (Baddeley, 1992) and therefore some participants may have focused on one goal more so than the other.

One of the limitations in Study 2 is the interaction that demonstrates that the expert model allowed for more improvement, had a difference between groups at pre-test which may be have driven the interaction. Additionally the other groups reached scores that were close to the maximum; therefore the measurement tools may not have afforded the other groups an opportunity to improve

These studies have created new questions and future directions. Future studies should begin to compare tasks of varying complexity. It is important to examine the effectiveness of observational learning of models with different skill levels on varying complexities of tasks. One possible means to accomplish this is to use a segmented timing task and vary the complexity of the task by varying the number of segments that need to be acquired. Therefore the movements are similar; however the first group’s task would employ a three segmented task, the second group a five segmented task etc. Within each group there would be three sub-groups viewing either an expert model, novice model or the combination of the two. Along the same lines it is important to re-test Study 2 with a task that inherently contains multiple strategies. Therefore the task needs to have multiple manners of completing it to ensure the novice model is employing variation within the motor program. As we previously speculated that there may not have been any differences between the groups because the variation may have been with respect to scaling of the task.

4.7 Conclusion

The results from Study 1 and 2 have some important implications. Firstly Study 1 demonstrated support to the notion that learners who engage in observational learning are only able to extract and code relative timing information and not absolute timing (Scully & Newell, 1985). Therefore when we create videos or employ novice models it may be important to ensure that variability exists with respect the generalized motor program that are employed.

Additionally, in the context of an applied setting, the type of model viewed may not be as crucial. In that regardless if the model is a novice or expert the learner will still be able to acquire the new motor task. In the context of medical education this allows the use different teaching approaches to be employed. The students can learn in dyads using a student-centered approach, as the novice model was a suitable means to acquire a skill. Similarly learners can acquire new clinical skills by employing a teacher-centered approach, by simply viewing their instructor (expert) perform the task. Finally the combination of an expert and novice model was shown to be adequate therefore the learners could acquire new clinical skills by employing both approaches simultaneously.

CHAPTER IV: REFERENCES

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Appendices

Appendix A: Adjusted OSATS Checklist and Global Rating Scale

Excision of Lesion Score: _________

□ Holds knife perpendicular to tissue plane (incision is perpendicular to skin without flaps or skiving
□ Creates elliptical incision
□ Excision dimensions allow closure without puckering (length > 4x width)
□ Has half mm margins
□ Leaves "leasion" (black dot) in center intact

Suturing score: _________

□ Positions needle in driver appropriately (1/2 to 1/3 distance from tip)
□ Places suture following curve of needle
□ Passes needle through tissue with supination: pronates wrist to regrasp needle
□ Stitches are at same level in epidermis
□ Epidermis is apposed without gaps

Knot Tying Score: _________

Suture 1:
□ Starts instrument tie with square throw
□ Subsequent throws are square to previous
□ Crosses hands with each throw to place (secure) them square
□Ties knot without tissue strangulation (appropriate skin tension)
□Throws 6-7 knots

Suture 2:
□ Starts instrument tie with square throw
□ Subsequent throws are square to previous
□ Crosses hands with each throw to place (secure) them square
□Ties knot without tissue strangulation (appropriate skin tension)
□Throws 6-7 knots

Suture 3:
□ Starts instrument tie with square throw
□ Subsequent throws are square to previous
□ Crosses hands with each throw to place (secure) them square
□Ties knot without tissue strangulation (appropriate skin tension)
□Throws 6-7 knots

Respect of tissue:

1	2	3	4	5
Frequently used unnecessary force on tissue or caused damage by inappropriate use of instruments		Careful handling of tissue but occasionally caused inadvertent damage		Consistently handled tissue appropriately with minimal damage

Time and Motion:

1	2	3	4	5
Many unnecessary moves		Efficient time/motion but some unnecessary moves		Clear economy of movement and maximum efficiency

Instrument Handling:

1	2	3	4	5
Repeatedly make tentative or awkward moves with instruments by inappropriate use of instrument		Competent use of instruments but occasionally appeared stiff or awkward		Fluid moves with instruments and no awkwardness

Flow of Operation:

1	2	3	4	5
Frequently stopped operating and seemed unsure of next move		Demonstrated some forward planning with reasonable progression of procedure		Obviously planned course of operation with effortless flow from one move to the next

Knowledge of Specific Procedure:

1	2	3	4	5
Deficient knowledge. Needed specific instruction at most steps		Knew all important steps of operation		Demonstrated familiarity with all aspects of operation

Appendix B: Informed Consent for Study 1 (Participant)

McMaster University
Inspiring Innovation and Discovery

November 20th , 2014

LETTER OF INFORMATION / CONSENT

Variability in performance facilitates observational practice, but what type of variability is best?

Investigators:

Faculty Supervisor
Dr. Lawrence Grierson
Department of Family Medicine
McMaster University
Hamilton, Ontario, Canada
(905) 525-9140 ext. 28503
E-mail: griersle@mcmaster.ca

Student Investigator
Arthur Welsher
Department of Kinesiology
McMaster University
E-mail: arthur_welsher10@hotmail.com

Co-investigator
Dr. James Roberts
Department of Kinesiology
McMaster University
E-mail: robjames@mcmaster.ca

Purpose of the Study

Observing an individual perform a task can provide a lot of information and prepare the observer to physically do the task themselves. It has been demonstrated that observing a novice model is beneficial for the learning a new task because of their high rate or error and variability. We hope to identify whether viewing errors with respect to relative timing vs. absolute timing is more beneficial for observational practice.

Procedures involved in the Research

If you choose to participate in this study, you will be asked to complete 2 one hour sessions spaced 24 hours apart.

In the first session you will be asked to view 60 trials of a segmented timing task performed by a model. The task requires you to press 4 buttons in a particular sequence with specific relative and absolute time goals. The relative time is the time that elapses between each button press. The absolute time is the time that is requires you to finish the entire 4 button sequence. Feedback about each attempt will be provided on the monitor 5 seconds after each performance. After which you will perform 10 attempts, where you will physically attempt the task. When observing and performing the task, the goal is to finish the button presses in 3000ms with a relative time goal of 1:4:1:4: (300ms:1200ms:300ms:1200ms)Then you will return 24 hours later to complete a retention test where you will perform 10 more physical attempts of the task. After which you will perform two transfer tests where you will be asked to perform 10 more attempts with new goal specifications.

Potential Harms, Risks or Discomforts:

There are very minimal risks involved in this study as there are no invasive measures being used. There is minor physical risk of becoming fatigued from pressing the buttons over the study period. We encourage you to speak up if the task becomes difficult so that we may provide a break.

Potential Benefits

The benefits of this study to the scientific community are that it will further our understanding of observational learning. It will shed light on what aspects of a novice models performance are important for the observer. It is important to understand the mechanisms of observational learning as it is becoming more prevalent. Knowing how it functions can help us use it to its full potential in educational settings.

Payment or Reimbursement

There will be no payment or reimbursement for the study.

Confidentiality

You are participating in this study confidentially. I will not use your name or any information that would allow you to be identified. Your data will not be shared with anyone, except with your consent. All electronic data will be anonymized, coded and stored on a password protected computer. This computer and all hard copy documentation (i.e., signed consent forms) will be kept secure in Dr. Grierson's office (MDCL 3522) for 3 years following the completion of the project, after which time it will be destroyed. The data will only be seen by Arthur Welsher and Dr. Grierson. As soon as consent forms are signed and data is collected it will be immediately taken to Dr. Grierson`s office and appropriately stored. If the results are published, no names or identifying information will be released or published.

Participation and Withdrawal

Your participation in this study is voluntary and it is your choice to be part of the study or not. If you decide to be part of the study, you can decide to stop (withdraw), at any time, even after signing the consent form or part-way through the study. If you decide to withdraw, there will be no consequences to you. In cases of withdrawal, any data you have provided will be destroyed unless you indicate otherwise. Withdrawal must be done before the completion of the study, which is expected to be March 20th, 2015.

Information about the Study Results

I expect to have this study completed by approximately March 2015. If you would like a brief summary of the results, please let me know how you would like it sent to you.

Questions about the Study

If you have questions or need more information about the study itself, please contact me at:

Arthur Welsher (student investigator): arthur_welsher10@hotmail.com or 289 922-9232

This study has been reviewed by the McMaster University Research Ethics Board and received ethics clearance.

If you have concerns or questions about your rights as a participant or about the way the study is conducted, please contact:

McMaster Research Ethics Secretariat

Telephone: (905) 525-9140 ext. 23142

c/o Research Office for Administrative Development and Support

E-mail: ethicsoffice@mcmaster.ca

CONSENT

I have read the information presented in the information letter about a study being conducted by ___ of McMaster University.

I have had the opportunity to ask questions about my involvement in this study and to receive additional details I requested.

I understand that if I agree to participate in this study, I may withdraw from the study at any time. I have been given a copy of this form. I agree to participate in the study.

____

Name of Participant

_______________________________________ _____________________

Signature of Participant Date

Consent form administered and explained in person by:

____

Name

_____________________________________ _____________________

Signature Date

Appendix C: Informed Consent for Study 1 (Confederate)

November 20th , 2014

LETTER OF INFORMATION / CONSENT

Variability in performance facilitates observational practice, but what type of variability is best?

Investigators:

Faculty Supervisor
Dr. Lawrence Grierson
Department of Family Medicine
McMaster University
Hamilton, Ontario, Canada
(905) 525-9140 ext. 28503
E-mail: griersle@mcmaster.ca

Student Investigator
Arthur Welsher
Department of Kinesiology
McMaster University
E-mail: arthur_welsher10@hotmail.com

Co-investigator
Dr. James Roberts
Department of Kinesiology
McMaster University
E-mail: robjames@mcmaster.ca

Purpose of the Study

Observing an individual perform a task can provide a lot of information and prepare the observer to physically do the task themselves. It has been demonstrated that observing a novice model is beneficial for the learning a new task because of their high rate or error and variability. We hope to identify whether viewing errors with respect to relative timing vs. absolute timing is more beneficial for observational practice.

Procedures involved in the Research

In this study you will be asked to play the role of a model. You will be asked to perform 80 attempts of a segmented timing task. This task requires you to press 4 buttons in a particular sequence with relative and absolute time goals. The relative time, is the time that elapses between each button press. The absolute time is the time it requires you to complete the entire sequence. We will provide you with specific goals. As you progress through the 80 attempts immediate feedback will be provided so that the most accurate attempts may be completed.

We will provide you with gloves and ask you to remove any identifiable jewelry so that there is no identifiable information on the recording. We will simply be recording your hands. Therefore you will not be identifiable in the videos. We will be taking your relative time and absolute time of your performances and providing them to the participants who will be observing your attempts.

Potential Harms, Risks or Discomforts:

There are very minimal risks involved in this study as there are no invasive measures being used. There is minor physical risk of becoming fatigued from pressing the buttons over the study period. We encourage you to speak up if the task becomes difficult so that we may provide a break.

Potential Benefits

The benefits of this study to the scientific community are that it will further our understanding of observational learning. It will shed light on what aspects of a novice models performance are important for the observer. It is important to understand the mechanisms of observational learning as it is becoming more prevalent. Knowing how it functions can help us use it to its full potential in educational settings.

Payment or Reimbursement

There will be no payment or reimbursement for the study.

Confidentiality

You are participating in this study confidentially. I will not use your name or any information that would allow you to be identified. Your data will not be shared with anyone, except with your consent. All electronic data will be anonymized, coded and stored on a password protected computer. This computer and all hard copy documentation (i.e., signed consent forms) will be kept secure in Dr. Grierson's office (MDCL 3522) for 3 years following the completion of the project, after which time it will be destroyed. The data will only be seen by Arthur Welsher and Dr. Grierson. As soon as consent forms are signed and data is collected it will be immediately taken to Dr. Grierson`s office and appropriately stored. If the results are published, no names or identifying information will be released or published.

Participation and Withdrawal

Your participation in this study is voluntary and it is your choice to be part of the study or not. If you decide to be part of the study, you can decide to stop (withdraw), at any time, even after signing the consent form or part-way through the study. If you decide to withdraw, there will be no consequences to you. In cases of withdrawal, any data you have provided will be destroyed unless you indicate otherwise. Withdrawal must be done before the completion of the study, which is expected to be March 20th, 2015.

Information about the Study Results

I expect to have this study completed by approximately March 2015. If you would like a brief summary of the results, please let me know how you would like it sent to you.

Questions about the Study

If you have questions or need more information about the study itself, please contact me at:

Arthur Welsher (student investigator): arthur_welsher10@hotmail.com or 289 922-9232

This study has been reviewed by the McMaster University Research Ethics Board and received ethics clearance.

If you have concerns or questions about your rights as a participant or about the way the study is conducted, please contact:

McMaster Research Ethics Secretariat

Telephone: (905) 525-9140 ext. 23142

c/o Research Office for Administrative Development and Support

E-mail: ethicsoffice@mcmaster.ca

CONSENT

I have read the information presented in the information letter about a study being conducted by ___ of McMaster University.

I have had the opportunity to ask questions about my involvement in this study and to receive additional details I requested.

I understand that if I agree to participate in this study, I may withdraw from the study at any time. I have been given a copy of this form. I agree to participate in the study.

____

Name of Participant

_______________________________________ _____________________

Signature of Participant Date

Consent form administered and explained in person by:

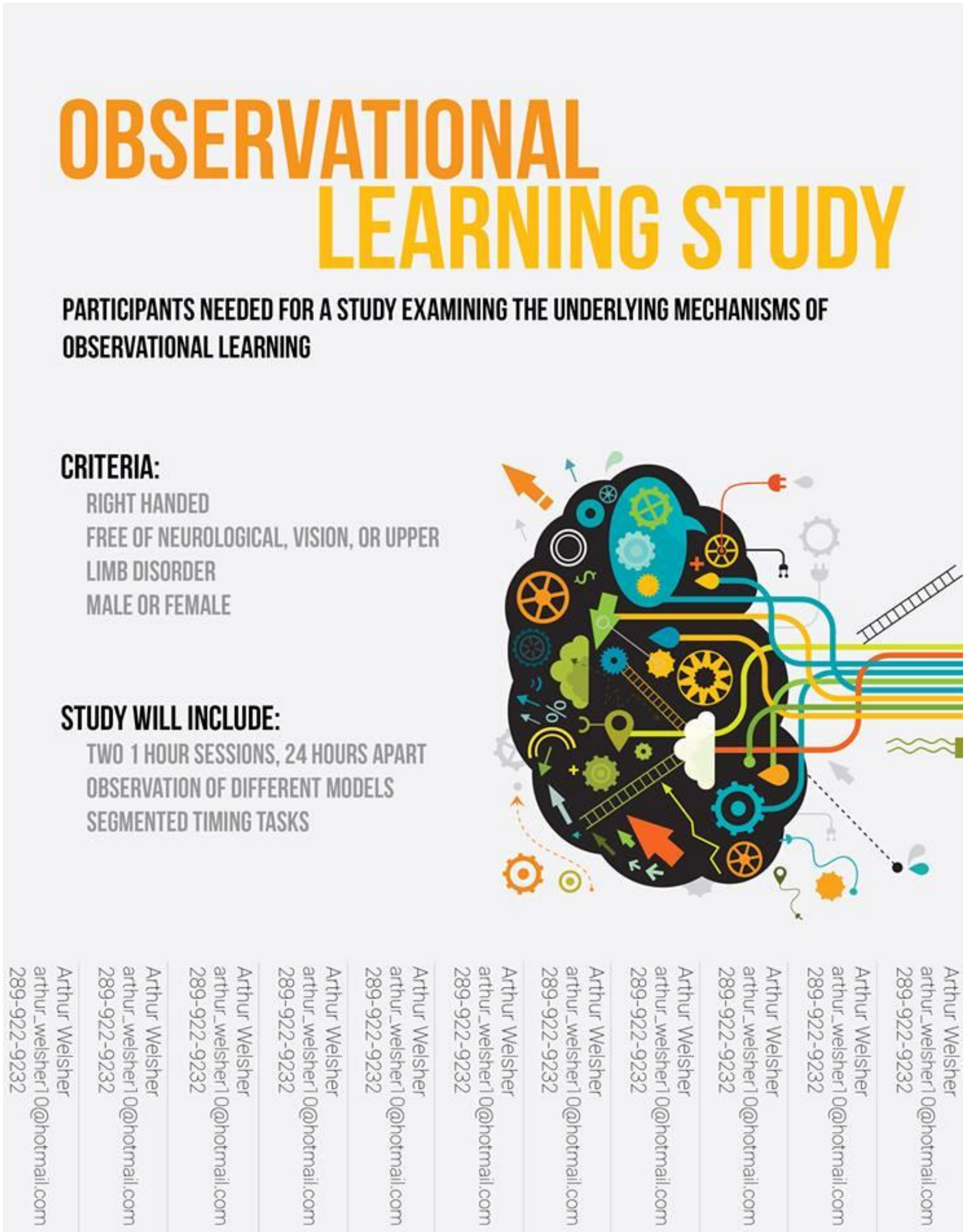
____

Name

_____________________________________ _____________________

Signature Date

Appendix D: Recruitment Poster (Study 1)



Appendix E: Consent form for Study 2

Hamilton Health Sciences — McMaster University — St. Joseph's Healthcare Hamilton

Hamilton Integrated Research Ethics Board
AMENDMENT REQUEST

REB Project #: 11-409

Principal Investigator: **Dr. Geoff Norman**
Dr. Lawrence Grierson

Project Title: Studies of Learning and Reasoning in Medicine

SUB-STUDY: Observational Practice and Educational Networking: Extending the Simulation-based Education beyond the Simulation Laboratory

Document(s) Amended with version # and date:

- Administrative Change - Add Sub-study: Observational Practice and Educational Networking: Extending the Simulation-based Education beyond the Simulation Laboratory
- Administrative Change - Dr. Lawrence Grierson is the Principal Investigator of this Sub-study
- Consent Form - Letter of Information/Consent Dated: 17 November, 2014
- Other - Synopsis of this Sub-study

Research Ethics Board Review
(this box to be completed by HIREB Chair only)

[X] **Amendment approved as submitted**

[ ] **Amendment approved conditional on changes noted in "Conditions" section below**

[ ] **New enrolment suspended**

[ ] **Study suspended pending further review**

Level of Review:

[ ] Full Research Ethics Board
[X] Research Ethics Board Executive

The Hamilton Integrated Research Ethics Board operates in compliance with and is constituted in accordance with the requirements of: The Tri-Council Policy Statement on Ethical Conduct of Research Involving Humans; The International Conference on Harmonization of Good Clinical Practices; Part C Division 5 of the Food and Drug Regulations of Health Canada, and the provisions of the Ontario Personal Health Information Protection Act 2004 and its applicable Regulations; For studies conducted at St. Joseph's Hospital, HIREB complies with the health ethics guide of the Catholic Alliance of Canada

S. Salama

Suzette Salama PhD., Chair
Raelene Rathbone, MB BS, MD, PhD, Chair

11/18/2014
Date

All Correspondence should be addressed to the HIREB Chair(s) and forwarded to:
HIREB Coordinator
293 Wellington St. N, Suite 102, Hamilton ON L8L 8E7
Tel. 905-521-2100 Ext. 42013 Fax: 905-577-8378

Appendix A- Consent Form

Hamilton Integrated
NOV 1 8 2014
Research Ethics Board

McMaster University

Program for Educational Research & Development

Faculty of Health Sciences
Michael G. DeGroote Centre for Learning and Discovery
Juravinski ERDC, Room 3510
1280 Main Street West
Hamilton, ON, Canada L8N 3Z5

Phone: 905-525-9140 x23114
Fax: 905-572-7099
Email: perd@mcmaster.ca
http://www.fhs.mcmaster.ca/perd

November 17th, 2014

LETTER OF INFORMATION / CONSENT

Observational Practice and Educational Networking: Extending the Simulation-based Education beyond the Simulation Laboratory

Investigators:

Principal Investigator
Dr. Lawrence Grierson
Department of Family Medicine
McMaster University
Hamilton, Ontario, Canada
(905) 525-9140 ext. 28503
E-mail: griersle@mcmaster.ca

Student Investigator
Arthur Welsher
Department of Kinesiology
McMaster University
E-mail: arthur_welsher10@hotmail.com

Purpose of the Study

This study will generate theoretical knowledge concerning the optimal application of video-based observational practice and educational networking approaches to simulation-based learning. It will also further develop, expand and improve an innovative, internet-mediated Observational Practice and Educational Networking (OPEN) system. This work will also expand our knowledge of simulation-based education and its impact in a distributed health profession education context.

Procedures involved in the Research

If you choose to participate in this study, you will be asked to attempt the elliptical excision skill in a simulation-based performance context, participate in a 14-day

Page 1 of 3

online, observational learning period, and then perform attempts of the simulated elliptical excision after the 2-week intervention, and again one month later. Prior to your first attempt, you will view a standard and error-free instructional video performed by a general surgeon that will demonstrate the correct elliptical excision (EE) procedure. After this attempt, you will then be allocated to an experimental group and given access to the OPEN system for 14 days where you are asked to view and assess 8 videos attempts of the EE procedure (approx.. one every other day).

Potential Harms, Risks or Discomforts:

There are no potential harms or risks associated with your participation in this study.

Potential Benefits

There are no direct benefits associated with your participation in this study. However, this work will assist the scientific community's understanding of observational learning in health professions education. It will contribute to the development of an effective and flexible observational practice and education networking learning environment.

Payment or Reimbursement

At the end of the experimental portion of the study, participants will be provided an opportunity to participate in an EE workshop that will be run by an experienced surgical resident.

Confidentiality

You are participating in this study confidentially. We will not use your name or any information that can be used to identify you. All electronic data will be anonymized, coded and stored on a password protected computer. This computer and all hard copy documentation (i.e., signed consent forms) will be kept secure in Dr. Grierson's office (MDCL 3522) for 3 years following the completion of the project, after which time it will be destroyed. The data will only be seen by Arthur Welsher and Dr. Grierson. As soon as consent forms are signed and data is collected it will be immediately taken to Dr. Grierson`s office and appropriately stored. If the results are published, no names or identifying information will be released or published.

Participation and Withdrawal

Your participation in this study is voluntary and it is your choice to be part of the study or not. If you decide to be part of the study, you can decide to stop (withdraw), at any time, even after signing the consent form or part-way through the study. If you decide to withdraw, there will be no consequences to you. In cases of withdrawal, any data you have provided will be destroyed unless you indicate otherwise.

Information about the Study Results

We expect this study to be completed by approximately March 2015. You may request a summary of the results after April 1st, 2015.

Questions about the Study

If you have questions or need more information about the study itself, please contact me at:

Arthur Welsher (student investigator): arthur_welsher10@hotmail.com or 289 922-9232

For further information, contact Lawrence Grierson, Principal Investigator at 905-525-9140 ext 22738.

If you have any questions regarding your rights as a research participant you can contact the Office of the Chair of the Hamilton Integrated Research Ethics Board at 905 521-2100, Ext. 42013.

CONSENT

I have read the information presented in the information letter about a study being conducted by ___ of McMaster University.
I have had the opportunity to ask questions about my involvement in this study and to receive additional details I requested.
I understand that if I agree to participate in this study, I may withdraw from the study at any time. I have been given a copy of this form. I agree to participate in the study.

____
Name of Participant

______________________________ ________________
Signature of Participant Date

Hamilton Integrated
NOV 18 2014
Research Ethics Board

Consent form administered and explained in person by:

____
Name

______________________________ ________________
Signature Date

Page 3 of 3