# The effects of control versus no control, within a dyad, for the acquisition of a novel motor skill.

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## Abstract

The motor learning literature has shown that alternating dyad practice (i.e. switching between Actor and Observer roles after each practice trial) is both an effective and efficient method of practice. The present experiment examined the effects of providing dyad learners with control over when to switch roles with their partner and investigated the potential differences between when the Actor had control versus the Observer. Further, this experiment investigated the different switching strategies adopted by the dyad learners, when provided control. During acquisition, participants performed a speed cup-stacking task, and returned approximately twenty-four hours later for delayed retention and sequence transfer tests. The results showed participants who controlled their role-switching schedule learned the task relatively similarly to those who did not have control, as well as to those who practice individually. Additionally, providing the Actors with control over their schedule resulted in equivalent learning outcomes to the Observers who were provided control. Finally, the learners who were provided control adopted various switching strategies, highlighting the dynamic nature of dyad practice. Overall, these novel findings suggest that dyad learners can control their role-switching schedule, without undermining learning, and thus provide further support for dyad practice as an effective and efficient method of practice.

Table of Contents

## List of Tables

## List of Figures

## 1.0 Review of Literature

### 1.1 Motor Learning

The acquisition of motor skills is a vital component of human life. Whether it is playing a sport, or simply walking down the street, our motor skills enable us to function optimally within the respective environment. In contrast to motor abilities, however, motor skills are not inherited (Fleishman & Bartlett, 1969). Rather, they are classified as movements that are “learned”, which therefore require practice or experience (Schmidt & Lee, 2013). Accordingly, in the context of motor learning research, the manner in which we learn motor skills, is a continued area of investigation.

Motor learning can be described as a set of internal processes, elicited by practice or experience, that cause relatively permanent changes to a learner’s motor skill performance (Kantak & Winstein, 2012). The relative permanence is a crucial aspect to the definition of motor learning and highlights one’s capability of maintaining a certain level of performance over time. This degree of permanency is also a distinguishing factor between learning and performance (Schmidt & Bjork, 1992). Performance is observable motor behaviour that occurs during practice, while learning represents the ability of this practiced behaviour to be sustained over time (Kantak & Winstein, 2012). In this regard, performance can be directly measured through changes in movement parameters, such as movement accuracy (Kantak & Winstein, 2012). However, motor learning cannot be measured directly, but rather inferred through changes in motor performance, over time (Kantak & Winstein, 2012).

The process of acquiring a motor skill typically includes three primary phases. The first phase of motor learning is practice. This phase is often referred to as the encoding phase and includes the “online” physical practice of a motor task. The encoding phase is primarily responsible for the formation of a motor memory (Kantak & Winstein, 2012). Approximately 4-6 hours subsequent to the practice phase, the learner begins to experience consolidation processes, which occurs in the absence of physical practice (Robertson, 2009). This is a critical phase to the process of motor learning, as it is responsible for strengthening the motor memory that was created during on-line processing (Walker, Brakefield, Morgan, Hobson, & Stickgold, 2002). Research has demonstrated that the consolidation phase is a time-dependent process that requires the learner to undergo sleep (Nettersheim, Hallschmid, Born, & Diekelmann, 2015; Robertson, Pascual-Leone, & Miall, 2004). To ensure sleep has occurred, research suggests the consolidation phase be a minimum of 24 hours, starting from the end of the acquisition phase to the beginning of the retrieval phase. Accordingly, sleep is a critical element to the process of motor learning (Krakauer & Shadmehr, 2006; Walker et al., 2002).

Motor learning is inferred when the learner is required to retrieve the motor plan from long term memory (Walker et al., 2002). Learning is inferred from a retention test, where the learner performs the motor task without external feedback (i.e., KR) (Salmoni, Schmidt, & Walter, 1984). The retention test assesses the relative permanence of the level of performance achieved in the acquisition phase, where the effects of the experimenter-determined practice conditions are no longer present (Christina & Shea, 1993; Salmoni et al., 1984). A transfer test occurs subsequent to the retention test, but rather is utilized to assess a variation of the practiced skill (Kantak & Winstein, 2012). For example, if the motor skill to be learned is a stabilometer balance task, an appropriate retention test would be balancing on a stabilometer, while an appropriate transfer test would be balancing on a bosu ball. Ultimately, the transfer test is responsible for assessing the generalizability of the motor plan (Kantak & Winstein, 2012).

**1.2 Dyad Learning**

Traditionally, it was thought that individual practice is the ideal way to train long-term retention of motor skills (Granados & Wulf, 2007; McNevin, Wulf, & Carlson, 2000; Shea, Wulf, Whitacre, 1999). From an applied standpoint, sport and rehabilitation practitioners place great emphasis on improving long-term retention and transfer of motor skills (Shea et al., 1999). What parallels individual practice, however, is increased time and costs spent on related equipment and personnel, required for one-on-one training protocols (Granados & Wulf, 2007). Therefore, individual practice lacks in training efficiency. Accordingly, researchers have addressed the importance of training efficiency, by examining different protocols that require motor skill acquisition by two or more learners simultaneously (Bjerrum, Eika, Charles, & Hilberg, 2014).

A training method that considers both training effectiveness and efficiency, involves practicing in pairs, or what is referred to as dyad practice. In the realm of motor learning, dyad practice can be described as two individuals practicing a motor task in the presence of each other, either in concurrent, dual control, or alternating fashions. Training protocols where peers practice in pairs have been examined in various domains, such as human factors (Shebilske, Regian, Arthur, & Jordan, 1992) and surgical skill training (Bjerrum et al., 2014). The following section highlights the different training methods used within dyad practice environments.

Dyad learning research was originally derived from the human factors literature. In 1992, Shebilske and colleagues created a novel dyadic training approach, named the active interlocked modeling (AIM) protocol. Essentially, the AIM protocol is a dual control method of practice, whereby learners are paired in dyads to concurrently achieve a common goal. Specifically, one member of the dyad controls part of the task while interlocked with a partner who controls the other half of the task. Throughout the execution of the complex task, both partners are required to act and react to the actions of their partner (Shebilske et al., 1992). In addition, the learners switch roles on alternate trials to allow familiarity on both aspects of the task. Ultimately, both partners experience hands-on practice on both parts of the task and observe their partner's actions to learn the connection between parts (Sanchez-Ku & Arthur, 2000). In this realm of human factors research, the AIM protocol typically incorporates the Space Fortress (SF) video game as the complex task, where the goal is to destroy a centrally located fortress by controlling (i.e., joystick or desktop mouse) an in-game fighter ship (Arthur, Day, Bennet, McNelly, & Jordan, 1997; Sanchez-Ku & Arthur, 2000; Shebilske et al., 1992; Shebilske, Jordan, Goettl, & Day, 1999 experiment 1). Thus, while one member of the dyad is controlling the joystick, the other member is concurrently controlling the desktop mouse.

In these traditional dyad learning experiments, participants practiced the SF video game in dyads (i.e., the AIM protocol), or individually (Arthur et al., 1997; Arthur, Jefferey, Shebilske, & Young, 1996; Sanchez-Ku & Arthur, 2000; Shebilske et al., 1992; Shebilske et al., 1999 experiment 1). The participants played the video game in three-minute intervals during the practice session (Shebilske et al., 1992), followed by two individual trials of the SF task (Arthur et al., 1997), representing the immediate retention test. Results from this series of experiments (Arthur et al., 1997; Sanchez-Ku & Arthur, 2000; Shebilske et al., 1992; Shebilske et al., 1999 experiment 1) have consistently demonstrated no significant differences between participants who practiced the SF task in the AIM-dyad group and those who practiced the task individually. More importantly, from a motor learning perspective, no significant differences were found between the groups' total in-game score on 24-hour delayed retention tests (Shebilske et al., 1999 experiment 3), or on a reacquisition period following an 8-week non-practice interval

(Arthur et al., 1997). The absence of significant differences between the groups in these experiments highlight a prominent benefit to practicing a motor task in pairs. Specifically, these results demonstrate training efficiency, such that those who practiced in the AIM-dyad group performed equivalently to those who practiced individually (Arthur et al, 1997; Shebilske et al., 1999 experiment 1). The authors concluded that the AIM-dyad protocol effectively facilitated acquisition of the task similar to individual training, suggesting training efficiency of the AIM-dyad protocol.

Moreover, early research of the AIM-dyad protocol examined male participants, exclusively (Arthur et al., 1995, 1997; Shebilske et al., 1992). Later researcher, however, extended the dyad protocol to female participants and showed further support for the AIM-dyad protocol such that no significant differences were found between females who practiced in the AIM-dyad group and females who practiced individually (Sanchez-Ku & Arthur, 2000). Overall, the AIM-dyad protocol has shown to be an efficient method of training in both males and females.

More recently, research in surgical skill training has adopted similar protocols to that of the AIM-dyad group, such that participants practice complex tasks in either pairs or individually (Bao, He, & Zheng, 2018; Räder et al., 2014). This line of research has examined dyad protocols in laparoscopic surgery (Bao, He, & Zheng, 2018; Kowalewski et al., 2019), bronchoscopy (Bjerrum et al., 2014), lumbar puncture (Shanks, Brydges, Brok, Nair, & Hatala, 2013), and coronary angiography (Räder et al., 2014) tasks. This form of dyad practice typically includes alternating practice, rather than concurrent (i.e., the SF task). In a dyad-alternate protocol, one member of the dyad practices the task while the other partner observes (Bjerrum et al., 2014). Surgical skill training typically incorporates dialogue into the protocol, such that the learners practicing in dyads are encouraged to discuss strategies with each other, to aid their skill acquisition (Shanks et al., 2013).

The surgical skill training experiments have assessed learning using delayed retention tests (Bjerrum et al., 2014, Rader et al., 2014; Shanks et al., 2013). For instance, in 2014, Bjerrum and colleagues examined individual compared to dyad practice in the learning of a bronchoscopy simulation-based task. The results revealed no significant differences between the dyad and individual groups, on all measures (i.e., percentage of segments entered per minute, percentage of segments entered, procedure time, red-out time, and number of wall collisions) on both the immediate and delayed (3-week) retention tests. Further, another study also examined individual vs dyad practice but for a lumbar puncture simulation-based task (Shanks et al., 2013). The participant's performance was evaluated by raters blind to the purpose of the experiment using a validated 5-point global rating scale (GRS). The results from this study also demonstrated no significant differences between the individual and dyad groups on both the immediate and delayed (6-week) retention tests. Although these experiments (Bjerrum et al., 2014; Räder et al., 2014; Shanks et al., 2013) utilized various tasks, the results from the delayed retention tests highlight the efficiency benefits associated with practicing surgical skills in pairs. It has been concluded that practicing surgical skills in a dyad environment is as effective for skill acquisition, but also more efficient, than individual practice (Bjerrum et al., 2014, Räder et al., 2014; Shanks et al., 2013).

Although dyad practice is prevalent across certain domains of research (i.e., human factors and surgical skills training), there is limited research concerning the effects of practicing in pairs in traditional motor learning contexts. In 1999, Shea, Wulf, and Whitacre examined the benefits of dyad practice using a complex balance task. Participants were instructed to practice balancing on a stabilometer either individually, or in pairs. Participants who practiced the task in pairs were further assigned to either the dyad-alternate condition, or the dyad-control condition. Those assigned to the dyad-alternate condition followed an alternating practice schedule, whereby one partner physically practiced the task while the other observed and following each practice trial the partners would switch roles (i.e., Actor and Observer). In the dyad-control group, one partner completed all physical practice trials, while the other partner observed, before switching roles (i.e., Actor and Observer). Both dyad groups were afforded the opportunity to engage in undirected conversation, such that they could discuss certain movement strategies to aid their skill acquisition. Those assigned to the individual group practiced the task in the absence of a partner, and therefore lacked the opportunity to observe another learner or engage in dialogue.

For the 24-hour delayed retention test, all participants (regardless of their assigned group) were instructed to perform individually. The results showed that those who initially practiced in the dyad-alternate group (i.e., switched roles following each trial) had lower root mean square error (RMSE) (i.e., better performance) compared to those in both the dyad-control and individual groups. Further, those in the dyad-control group also outperformed (i.e., lower RMSE) those in the individual group. Therefore, based on the results from the dyad-alternate group, it was concluded that interspersing physical practice with observation, and permitting the discussion of movement strategies amongst pairs, was a beneficial means of producing effective and efficient learning outcomes (Shea et al., 1999).

A follow-up study, conducted by Granados and Wulf (2007), investigated whether the learning benefits from Shea, Wulf, and Whitacre (1999) were derived from the undirected dialogue between partners, the observation of another learner, or a combination of both variables.

Participants in this experiment were instructed to perform a speed cup-stacking task, in one of four groups: observation with discussion, observation with no discussion, discussion with no observation, and no observation with no discussion. Following a 24-hour retention interval, results from the delayed retention test showed that both groups that had the opportunity to observe another learner practice the task, produced faster movement times (i.e., better performance), compared to both groups that did not. Therefore, it was concluded the learning advantages associated with dyad practice were primarily attributed to the opportunity to observe another learner, independent of the opportunity for dialogue.

With regards to observational learning, there is further evidence to show its effectiveness when interspersed with physical practice, in the absence of dialogue**.** In 2000, Shea, Wright, Wulf, and Whitacre, conducted a set of experiments to examine the effectiveness of physical and observational practice for the acquisition of a novel video-game task. Participants were assigned to one of three experimental groups: physical practice, observational practice, or control. Participants in the observational group observed participants in the physical practice group and therefore observed a learning model, as the physical practice participants were novel to the task. Participants in the control group simply met with the experimenter, without discussing nor viewing the task. Results from the 24-hour delayed retention showed a main effect for Group, such that the physical practice group performed with lower RMSE (i.e., better performance) than the observational group, while both physical and observational groups performed with lower RMSE than the control group. Further, while the results from the 24-hour delayed transfer test showed both groups had lower RMSE than the control group, there were no significant differences between the physical and observational groups. These results first suggest that observational practice on its own is inferior to physical practice alone, with regards to motor learning. However, the lack of significant differences shown on the transfer test provide insight to the general task characteristics (i.e., coordination patterns, strategies, etc.) that can be acquired through observational practice.

In Shea et al. (2000) experiment 2, the researchers examined pure physical practice in comparison to the combination of observational and physical practice, for the same motor task examined in experiment 1. Although the task and procedure were similar to experiment 1, the participants in the physical practice group in experiment 2 did not have an observer watch them practice. Instead, the combined group practice in dyads, such that they followed a traditional turn taking schedule of switching between Actor and Observer roles after each practice trial. Further, participants in the combined group were prohibited from conversing with their partner, throughout practice. Results from the 24-hour delayed retention test showed no differences between the combined and pure physical practice groups, but the combined group performed significantly better than the physical practice group on the delayed transfer test. The researchers suggested that both practice types could have afforded the learners with unique information that differentially contributed to their task success. It was concluded from both experiments 1 and 2, that the combination of both practice types allows for unique learning experiences that are superior to either practice type alone.

A more recent study investigated the effects of concurrent vs turn-taking dyad practice for the learning of a complex balance task (Karlinsky & Hodges, 2018). In the concurrent group, partners would practice the balance task at the same time and observe one another while physically practicing the task. In the turn-taking group, partners would take turns practicing and observing one another. An individual group was also included, in which participants practiced the task alone. The results from this experiment showed relatively similar RMSE amongst all three groups. In addition, the subjective ratings amongst dyad participants demonstrated that concurrent practice was more distracting compared to turn-taking practice, although not detrimental to their performance. Overall, these results suggested that both forms of dyad practice (i.e., concurrent and turn-taking) are viable means of producing both effective and efficient learning outcomes (Karlinsky & Hodges, 2018).

Overall, practicing a motor task in pairs has proven advantageous for efficient motor skill learning, with observation suggested as a key element involved in the process of dyad learning (Granados & Wulf, 2007). In fact, both concurrent and alternating dyad procedures are equally beneficial to learning, although concurrent practice has been reported by learners as more interfering than alternating practice (Karlinsky & Hodges, 2018). What remains unknown, however, are the effects of control over role-switching within a dyad practice context. Specifically, it is unclear how dyad learners would choose to organize the role-switching schedule with their partner, and the subsequent effects on learning.

### 1.3 Self-Controlled Practice Schedules

A well-documented area of motor learning research is that of self-controlled practice. This domain of research continuously shows that providing learners with control over certain variables within their practice environment, enhances motor skill acquisition (for review see Wulf, 2007). For example, the learning advantages have been shown when learners have the opportunity to control their feedback schedule (Patterson, Carter, & Sanli, 2011; Wulf, 2007; Patterson & Carter, 2010; Chiviacowsky & Wulf, 2002; Janelle et al., 1995, 1997), the use of a physical assistive device (Wulf & Toole, 1999), task difficulty (Andrieux, Danna, & Thon, 2012), task switching during multi-task learning (Keetch & Lee, 2007; Wu & Magill, 2011), model observation (Wrisberg & Pein, 2002; Wulf, Rupauch, Pfieffer, 2005), and the total quantity of practice (Aiken, Post, Hout, Fairbrother, 2020; Post, Fairbrother & Barros, 2011; Post, Fairbrother, Barros & Kulpa, 2014).

Self-controlled practice has been established as a viable learning technique, based on the comparison to yoked conditions. A yoked condition consists of participants matched to participants in the self-control group, such that they replicate the same practice schedule as their self-controlled counterpart (Hansen, Pfeiffer, & Patterson, 2011). The participants in the yoked condition, however, do not have the opportunity to choose their practice schedule, which in turn has been shown to result in inferior learning (for an exception see Barros, Yantha, Carter, Hussein, Ste-Marie, 2019; or Hansen et al., 2011) compared to their self-controlled counterparts (Wrisberg & Pein, 2002; Wulf & Toole, 1999; Wu & Magill, 2011). For instance, Janelle and colleagues (1997) examined right-handed participants practicing a left-handed throwing task. They allowed the self-control group to choose when they wanted to receive knowledge of performance (KP) feedback, concerning their throwing form. The yoked counterparts were void the opportunity to choose when they wanted feedback, but rather received feedback following the same trials as their self-controlled counterpart. Results from the delayed retention test demonstrated that the learners in the self-controlled group performed with better form and accuracy compared to their yoked counterparts.

In a similar context, Wulf, Raupach, and Pfieffer (2005) examined self-control over the observation of a skilled model, for the learning of a basketball jump shot. Participants assigned to the self-control group were able to view the video of the model whenever they wanted and as many times as they requested during the acquisition session. The participants in the yoked group matched the observation schedule of their self-control counterpart. The results from the delayed (1-week) retention test showed that the participants in the self-control group performed with significantly better movement form compared to their yoked counterparts. Overall, it was concluded that the benefits of self-control persist to controlling the frequency of observing a modelled demonstration.

The established benefits of self-controlled practice have been conceptualized to be derived from two different theoretical perspectives. The first perspective predicts that allowing learners to choose when they receive feedback fulfills their psychological need for autonomy (Hartman, 2007; Sanli, Patterson, Bray, & Lee, 2013; Wulf & Toole, 1999), increases motivation (Chiviacowsky & Wulf, 2002), and increases feelings of self-efficacy (Andrieux et al., 2012), resulting in enhanced motor skill acquisition. This perspective has been conceptualized through the OPTIMAL (Optimizing Performance through Intrinsic Motivation and Attention for Learning) theory (Wulf & Lewthwaite, 2016). The OPTIMAL theory predicts motivation and attention are critical to our understanding of motor learning. In this context, learners may become more motivated if given feedback when it is wanted, and less motivated when it is not (Chiviacowsky, Wulf, Wally, & Borges, 2009). Chiviacowsky and Wulf (2002) found that learners who chose when to receive feedback on a sequential timing task outperformed (i.e., less absolute timing errors) their yoked counterparts on the 24-hour delayed transfer test. The researchers provided the self-control learners with a questionnaire regarding when and why they requested feedback. The yoked participants were provided with a questionnaire asking if they had received feedback at the right times, and if not, when they would have preferred it. The results from this questionnaire showed that the learners in the self-control group requested feedback following presumed “good” trials, while the yoked learners did not experience feedback following “good” trials to the same extent. In terms of the OPTIMAL theory, it is predicted that motor performance is enhanced when positive outcomes are anticipated, due to the trigger of dopaminergic responses (Wulf & Lewthwaite, 2016). In addition to enhanced expectancies, the OPTIMAL theory also predicts that when a learner is afforded the opportunity for choice (i.e., self-controlled practice), the combination of both variables contributes to efficient goal-action coupling. In this regard, the researchers argued that receiving feedback following "good" trials could be more motivating to replicate that successful trial, rather than to correct for errors on subsequent trials. Based on the OPTIMAL theory, these results suggest that success within an autonomy-supportive environment (i.e., self-controlled practice) is highly associated with motivation (Wulf & Lewthwaite, 2016).

The second theoretical perspective, termed the information-processing perspective, proposes that self-controlled practice allows the learner to experience a greater engagement in cognitive processes, leading to enhanced motor skill acquisition (Barros et al., 2019). More specifically, it has been suggested that self-controlled practice results in deeper information processing (Janelle et al., 1995, 1997), increased task recall (Post, Fairbrother, & Barros, 2011), enhanced feedback processing (Grand et al., 2015), increased preparation time (Post et al., 2014), and enhanced error detection (Carter et al., 2014; Carter & Ste-Marie, 2017). This perspective depicts the learner as an active processor of information, rather than a learner simply going through the motions of a pre-determined practice schedule (Carter, Rathwell, & Ste-Marie, 2016). In 2005, Chiviacowsky and Wulf examined self-controlled feedback and whether the associated benefits were due to the ability to exercise choice itself, or with the timing of the choice. They compared two self-controlled groups: Self-Before and Self-After. In the Self-Before group, they allowed participants to decide whether or not they wanted to received feedback following the upcoming trial, prior to its initiation. In the Self-After group, they allowed participants to choose whether or not they wanted feedback after they had completed the trial. The results showed that the participants in the Self-After group performed better on a 24-hour delayed transfer test, compared to those in the Self-Before group. The researchers argued the participants in the Self-After group were presumably involved in deeper error estimation processes compared to the Self-Before group, in deciding whether or not the feedback would be useful based on their preceding trial. However, there was no measure of error estimation within the experimental design and the researchers also failed to include yoked groups. Therefore, the opportunity to provide any mechanistic conclusions for the associated benefits of self-controlled feedback schedules was limited.

In 2014, Carter, Carlson, and Ste-Marie replicated and extended the work of Chiviacowsky and Wulf (2005), by including a measure of error estimation as well as yoked groups. They incorporated the same Self-Before and Self-After groups, but also included a Self-Both group that could choose whether or not they wanted feedback before performing a trial but could then change or stay with their original choice following the completion of the trial. They also introduced yoked groups for each self-control group, as well as an error estimation measure during retention and transfer. The results from the 24-hour delayed retention and transfer tests revealed the Self-After and Self-Both groups were both significantly more accurate than the Self-Before group. Further, the Self-After and Self-Both groups did not statistically differ from each other, but both had significantly less absolute error than their respective yoked counterparts, while the Self-Before group did not significantly differ from their yoked counterpart. Thus, having the option to request KR after motor execution lead to superior motor skill acquisition. In addition, the Self-After and Self-Both groups were significantly more accurate in evaluating their performance compared to the Self-Before group. It was concluded that the advantages associated with a self-controlled KR schedule were primarily attributed to the informational factors involved in processing feedback for the development and strengthening of one's error detection and correction mechanism.

**1.3.1 Self-Control in Dyad Practice**

With the recent interest of more efficient training methods, the self-control literature has been extended to dyad practice environments. For instance, in 2001, Wulf, Clauss, Shea, and Whitacre examined the effects of self-control in a dyad practice environment, for the learning of a ski-simulator task. Twenty-six adult participants were recruited and randomly assigned as either a self-control partner or a yoked partner. Each self-control participant was paired with a yoked participant to form a dyad. The participants practiced the task in an alternating fashion, such that partner one physically practiced while partner two observed. The partners switched roles after each practice trial, until both partners completed a total of seven physical and seven observational practice trials, each. All participants were instructed that the goal was to produce the largest possible amplitude, and to do so, they could use ski poles to aid their skill acquisition. Partner one (i.e., self-control) could choose when to use the poles, while partner two (i.e., yoked) had to follow the same pole/no-pole schedule. Results from the 24-hour delayed retention test revealed that the participants who were able to choose when to use the poles performed more effectively compared to their yoked partners, with respect to relative force onset. These results suggest the advantages of self-controlled practice persist within a dyad practice environment (Wulf et al., 2001).

A more recent study examined dyad practice and whether a partner's multi-skill task-switching influenced the practice behaviours and overall learning of a partner with self-control (Karlinsky & Hodges, 2017). Specifically, ninety-four female participants were randomly assigned to a dyad and further assigned within each dyad as Partner 1 (P1) or Partner (P2). All participants assigned as P1 practiced 3 differently-timed key-stroke sequences in either a blocked, random, or self-controlled order, while all P2s self-controlled their practice schedule. Participants assigned as P1 in the self-controlled group did not observe their partner practice, for control purposes. The purpose of this experiment was to investigate whether the practice behaviours and learning outcomes of self-controlled learners could be modulated by a partner's practice schedule for multi-skill learning. The results showed that participants in the self-controlled condition adopted both their own error-dependent switching strategies (i.e., switching key-stroke sequences following perceived "good" trials), as well as partner-dependent switching strategies, with the partner's practice schedule influencing both switching frequency and sequence selection. The results further showed that a partner's practice schedule also impacted the self-controlled partner's learning. The self-controlled participants whose partners practiced in a random order, resulted in better timing accuracy compared to those who performed blocked practice, for both partners in the immediate and 24-hour delayed retention tests. These results illustrate how self-controlled practice behaviours and learning outcomes were influenced by a partner's practice schedule, within a turn-taking dyad practice environment.

In summary, the benefits of self-controlled practice have been well established within the motor learning literature. For example, the advantages have been shown when allowing learners to control their feedback schedule (Chiviacowsky & Wulf, 2002; Patterson et al., 2011), model observation (Wrisberg & Pein, 2002), the use of a physical assistive device (Wulf & Toole, 1999), task switching during multi-task learning (Keetch & Lee, 2007), task difficulty (Andrieux et al., 2012), and total amount of practice (Aiken et al., 2020). Moreover, the self-control literature has been extended to demonstrate the benefits within a dyad practice environment (Wulf et al., 2001), and how a partner's practice schedule can modulate both the practice behaviours and learning outcomes of those who control their own practice schedule (Karlinsky & Hodges, 2017). What remains unknown, however, are the effects of self-control when both partners within a dyad practice context are provided choice over their practice schedule. Specifically, it is unclear how each partner's choices would influence one another's behaviours and the subsequent effects of motor learning.

**1.4 Peer-Controlled Practice Schedules**

More recently, researchers have examined the potential learning benefits when control is afforded to a peer. For example, in 2015, McRae, Patterson, and Hansen, examined the effects of a peer-controlled KR feedback schedule. The researchers randomly assigned the participants to one of three experimental groups: peer, peer-controlled learner, or self-controlled learner. All participants recruited for this study were novel to the task. The task was a serial-timing task with a goal movement time of 2500ms. For the acquisition phase, the participants in the peer group were paired with a participant in the peer-controlled learner group. Upon arrival to the laboratory, each member of the pair was assigned to a different room. Throughout practice, the participant in the peer group received feedback concerning the peer-controlled learner's performance. This feedback included the learner's outcome (i.e., correct or incorrect), the direction of their error (i.e., too fast or slow), and the timing error (i.e., constant error). The participant in the peer-controlled learner group only received their feedback if the peer chose to provide it. The participants in the self-control group did not have a peer-counterpart, but rather controlled when they received KR, themselves. Based on the absolute error on KR and no-KR trials as well as self-report data, the participants in the peer group provided the participants in the peer-controlled learner group with KR following good and bad trials equally, while the self-controlled learners requested KR primarily following good trials. Further, the results from the

24-hour retention test showed that the peer-controlled learners and self-controlled learners acquired the task similarly based on absolute and constant error. The delayed retention test further indicated that participants in the peer-control group were more consistent (i.e., in regard to variable error) compared to those in the self-control group. It was concluded that peers with no prior task experience adequately organized feedback schedules that facilitated the skill acquisition of their paired learners, similar to that of self-controlled learners (McRae et al., 2015).

A follow-up study was conducted by Patterson, Hansen, and McRae (2019), to further examine peer-controlled KR schedules, but as a function of task experience. The participants were pseudo-randomly assigned to one of five groups: experienced peer (EP), learner with ‘experienced peer’(L-EP), inexperienced peer (IP), learner with ‘inexperienced peer’ (L-IP), or control (CO). Participants in the EP group first practiced the serial-timing task themselves while self-controlling their KR schedule. Similar to McRae et al. (2015), the inexperienced peers had no prior experience with the task, prior to providing KR to their learner counterpart. The participants in the control group merely observed the experienced peer’s KR displayed on a computer screen, simply to control for any potential social influences that might arise during the paired practice in the acquisition phase. The results from the 24-hour delayed retention test showed the participants learned the task similarly, independent of the peer’s prior task experience. In addition, peers with prior task experience provided KR less frequently compared to the peers with no prior task experience. Overall, it was suggested that independent of task experience, peers can provide KR to a fellow learner in such a way that facilitates skill acquisition (Patterson et al., 2019).

Karlinsky and Hodges (2014) examined peer- vs self-controlled practice schedules for the learning of three different key-stroke sequences. All participants were randomly paired and assigned to either the self-controlled or peer-controlled group. In each pair (regardless of assigned group), one member was assigned as the Actor, who physically practiced each of the three key-stroke sequences. The Actors in the self-controlled group decided which of the three sequences they wanted to practice prior to each trial, while their partner observed them. Alternatively, the Actors in the peer-controlled group had their partner chose which pattern they would practice, instead. The results from the 24-hour delayed retention test revealed that the Actors generally performed with lower movement time error (i.e., better performance) than that of their partners. Further, there were no statistically significant differences between the self-controlled Actors and the peer-controlled Actors. Lastly, subjective ratings showed that peer-controlled practice was rated as more motivating and enjoyable compared to self-controlled practice. The results from this experiment suggest that through observation, peers can adequately control another learner's practice schedule, facilitating motor skill acquisition. Ultimately, these results highlight an alternative practice method to self-controlled practice.

Overall, our understanding of peer-controlled practice schedules for motor skill acquisition remains relatively limited. What we do know, based on the present review of the literature, is that both inexperienced and experienced peers can adequately control the practice schedule of another learner, with regard to KR (McRae et al., 2015; Patterson, et al., 2019). Furthermore, we know that peers are also able to sufficiently control another learner's practice schedule, when acquiring multiple different motor tasks (Karlinsky & Hodges, 2014). What remains unknown, however, are the effects of a peer-controlled practice schedule within a dyad practice environment when both members of the pair are physically practicing. In practical situations, the peers who are provided with the control over another learner's practice are also physically involved in practicing the motor task themselves (i.e., captain-run practices). In the previously mentioned experiments, the peers controlling the practice schedules were not practicing the motor task, but rather controlled the practice schedule merely through observation. Therefore, identifying how a peer controls another learner's practice schedule while also physically engaged in the task themselves, would extend our theoretical and practical understanding of self-control provided in a dyad practice environment.

## 2.0 Introduction

### 2.1 Thesis Introduction

Motor learning research primarily examines practice variables that enhance the long-term retention of motor skills (Granados & Wulf, 2007). This is also true from an applied standpoint, such that practitioners (i.e., in sport, rehabilitation, etc.) typically create training protocols with the goal of maximizing the retention and transfer of the practiced motor skills (Shea et al., 1999). However, from a practical perspective, it is also important to consider the efficiency of a training protocol, referring to the associated costs such as money and time spent on related personnel and equipment (Granados & Wulf, 2007). Therefore, an ideal training protocol should be recognized as both effective and efficient. One such protocol is that of dyad practice, which refers to two individuals practicing a motor skill in the presence of one another, either in a concurrent, dual-control, or alternating fashion.

Dyad practice has been proven to be both an effective and efficient practice method in many domains of research, including human factors (Shebilske et al., 1992) and surgical skills training (Bjerrum et al., 2014). The human factors research has shown that practicing a complex task (i.e., Space Fortress video game) in dyads, such that each member of the dyad controls half of the task (i.e., joystick or keyboard), does not impair learning, compared to practicing the task individually (Sanchez-Ku & Arthur, 2000; Shebilske et al., 1992). Although participants in a dyad practice condition do not show enhanced learning compared to the participants who practiced individually, it does suggest a more efficient protocol as two participants are trained in the same amount of time previously required to train just one participant (Arthur et al., 1997; Sanchez-Ku & Arthur, 2000; Shebilske et al., 1992, 1999). Moreover, practicing surgical skills in dyads has also been proven to be more efficient than individual practice, with laparoscopy (Bao et al., 2019), bronchoscopy (Bjerrum et al., 2014), lumbar puncture (Shanks et al., 2013), and coronary angiography (Räder et al., 2014) tasks.

From a motor learning perspective, there remains limited research concerning the effects of dyad practice. Shea et al. (1999) compared the effectiveness of dyad versus individual practice for the acquisition of a complex balance task. The results of this experiment showed that practicing with a partner lead to lower RMSE compared to practicing the task individually. Therefore, the dyad protocol resulted in enhanced learning compared to those who practiced the task individually. These results showed that practicing in dyads was an efficient method of practice, as two participants were trained in the same time required for just one participant.

Observation of a partner and undirected dialogue have been suggested as the critical factors responsible for the learning advantages demonstrated in dyad practice (Shea et al., 1999). Specifically, interspersing observation with physical practice has been shown to be advantageous for skill learning (Shea et al., 2000; Wulf & Shea, 2002), as it provides the observer with pertinent information concerning movement strategies and coordination patterns, that might otherwise be difficult to detect when physically practicing the task (Granados & Wulf, 2007). Granados and Wulf (2007) examined whether the benefits of dyad practice are primarily due to observation, dialogue, or a combination of both variables. Their results showed that dialogue between practice trials provided no additional benefit to learning, and the advantages of dyad practice were primarily due to the opportunity to observe another learner practice.

Moreover, there is evidence to support varying types of dyad practice. For example, human factors research supports the use of dual control tasks whereby both learners control half of a complex task (i.e., control over a joystick or desktop mouse) in conjunction with one another, to achieve a common goal (i.e., destroy an in-game fighter ship) (Shebilske et al., 1992). Moreover, in 2018, Karlinsky and Hodges found that both concurrent and alternating methods of dyad practice resulted in similar RMSE, both of which were relatively the same as individual practice. Although both dyad groups learned the task similarly, subjective measures showed that concurrent practice was more distracting than the alternating method of practice (Karlinsky & Hodges, 2018).

There is considerable support for practice contexts under control of the learner (i.e., self-controlled) (Andrieux et al., 2012; Keetch & Lee, 2007; Patterson et al., 2011). The benefits of self-controlled practice have been established through the use of yoked conditions, in which participants experience the same practice schedule as a self-controlled counterpart, however without the choice. Post et al. (2015) concluded that the ability to control one's own amount of practice within a fixed time period led to more accurate performance as well as superior form scores, compared to their yoked counterparts, exemplifying more efficient learning. Additionally, Wulf and colleagues (2001) concluded that within a dyad practice environment, having the opportunity to control when to use an assistive device (i.e., ski poles), lead to more effective performance with regard to relative force onset, compared to the yoked counterparts. Overall, these studies demonstrate how providing a learner with control over the amount of practice trials

(Post et al., 2015) and task complexity (Wulf et al., 2001), leads to superior motor skill acquisition compared to learners who are not afforded choice. However, while the advantages of self-controlled practice are apparent, and research has proven alternating dyad practice to be both effective and efficient, it remains unknown if providing dyad learners with control over the role-switching schedule would provide additional learning benefits.

Two primary theoretical perspectives have been proposed to explain the underlying mechanisms responsible for the advantageous associated with self-controlled practice: information processing perspective and the OPTIMAL theory. The information processing perspective suggests that self-controlled practice engages the learner in deeper cognitive processing, resulting in enhanced motor learning (Barros et al., 2019). Conversely, the OPTIMAL theory proposes that an autonomy-supportive environment (i.e., self-controlled practice) enhances a learner's motivation, leading to superior skill acquisition (Wulf & Lewthwaite, 2016). For the present study, while we were primarily interested in the learning effects of controlled role-switching within a dyad, we included a subscale of the *Intrinsic Motivation Inventory* (IMI; Deci & Ryan, n.d.), named the *Task Evaluation Questionnaire*, to evaluate learner's subjective experiences related to the cup-stacking task. The inclusion of this questionnaire was exploratory in nature, but its purpose was to gain insight to the motivational mechanisms involved in such practice protocols.

Despite the identified benefits of self-controlled practice, many practical situations (i.e., a sport team practice) do not enable a learner to control certain aspects of their practice session. Rather, it is common for learners to utilize other individuals to facilitate their skill acquisition. For example, in a captain-run basketball practice (i.e., a practice in which the coach is not present), an athlete may rely on another teammate to provide them with performance feedback or a demonstration of the to-be-learned skill (McRae et al., 2015). Similarly, learners who participate in dyad training protocols work together and rely on one another to perpetuate their skill acquisition (Granados & Wulf, 2007; Shea et al., 1999; Shebilske et al., 1992). Previous research has shown that both experienced (Patterson et al., 2019) and inexperienced (McRae et al., 2015) peers can adequately control the KR schedule of another learner, in such a way that facilitates learning. Existing research has also shown that peers can control other learner's practice schedules when acquiring multiple different tasks, ultimately showing how peer-control can be used as an alternative method of practice (Karlinsky & Hodges, 2014). However, despite the frequent interaction of peers during motor skill acquisition, it remains unknown how a peer would control the practice schedule of another learner, when physically engaged in acquiring the motor skill, such as in a dyad training protocol.

The primary focus of the current experiment was to determine whether providing control over role-switching, within a dyad, would differentially impact the acquisition of a novel motor skill, compared to a traditional alternating dyad (i.e., no control and switching roles after each trial) and an individual control group (i.e., one member of the dyad completes all physical practice trials while a partner observes). Further, this experiment sought to examine potential differences between an Actor-Controlled and Observer-Controlled practice schedule, within an alternating dyad. Lastly, the final aim was to determine the role-switching strategies adopted by the participants when provided control within a dyad practice context. The specific research question is: does having control over the role-switching schedule, within a dyad, differentially impact skill acquisition compared to a traditional alternating dyad, and if so, does it matter which partner has the control? Due to the novelty of this experiment, as well as for clarity, the participants within each dyad will be referred to as either the Actor (i.e., the partner physically practicing the task) or the Observer (i.e., the partner observing). Therefore, the "peer-control" group will be referred to as "Observer-Controlled" while the "self-control" group will be referred to as "Actor-Controlled". The results from this research would extend our knowledge of dyad practice contexts and provide insight as to whether administering control over role-switching differentially modulates motor learning. Furthermore, this research would be significant to our understanding of self- and peer-controlled practice conditions, and how they may differentially impact skill acquisition when administered within an alternating dyad practice environment.

## 2.2 Experimental Predictions

Based on previous literature, the following predictions were made:

1. Participants in the Actor- and Observer-Controlled groups would demonstrate faster movement time scores compared to the participants in the individual Control group, on the post-, retention, and transfer tests.

   This prediction was based on existing dyad research that has shown practicing a motor task in pairs, is as effective as individual practice (Granados & Wulf, 2007; Karlinsky & Hodges, 2018; Shea et al., 1999). It was predicted, however, that having control over role-switching (i.e., either self- or peer-control) would provide additional benefits to skill acquisition, based on the self- and peer-control literature. This line of research has shown that providing control over certain practice variables to either the learner themselves or a peer, is beneficial for motor learning, compared to experimenter-controlled practice schedules (Carter et al., 2014; Chiviacowsky, 2014; McRae et al., 2015; Patterson et al., 2019).

2. Participants in the Actor- and Observer-Controlled groups would demonstrate faster movement time scores compared to the participants in the Dyad-Alternate group, on the post-, retention, and transfer tests.

It was predicted that participants who practiced in a dyad and were afforded control over when to switch roles (i.e., Actor- and Observer-Controlled groups) would demonstrate significantly faster movement time than learners who practiced in a dyad but were not afford control (i.e., Dyad-Alternate group). The self- and peer-controlled literature has shown how learners with self-control or a peer controlling their practice schedule tend to outperform learners who are not provided such control, both during practice and on retention and transfer tests (Karlinsky & Hodges, 2014; Keetch & Lee, 2007; McRae et al., 2014). Therefore, it was predicted that introducing control over role-switching to a dyad practice environment would result in faster movement times.

3. Participants in the Actor- and Observer-Controlled groups would show similar movement times on the post-test, but the Observer-Controlled group would perform superiorly (i.e., faster) on the retention and transfer tests.

During the post-test, it was predicted participants in the Actor- and Observer-Controlled groups would show similar movement times. This prediction was based on the work of Patterson et al. (2019), who demonstrated that learners with self-control and learners whose practice schedules were controlled by another peer, showed relatively similar error at the end of the acquisition period. In terms of the retention and transfer tests, however, it was predicted the Observer-Controlled group would perform superiorly compared to the Actor-Controlled group. This prediction was primarily based on the observational learning literature. For instance, in the Observer-Controlled, since the Observers were required to control the practice schedule for their partner, it was predicted they would be more attentive to their partner's performance compared to the Actor-Controlled group, who were only responsible for controlling the schedule while in the Actor role. Therefore, if the Observers controlling the schedule are more cognitively engaged in observing their partner practice, it was predicted it would lead to enhanced error detection and correction processes (Lee & White, 1990), and a stronger cognitive representation of the skill (Deakin & Proteau, 1998; Shea, Wright, Wulf, Whitacre, 2000). It was prediction, that this, in turn, would result in faster movement time scores on the delayed retention and transfer tests, compared to the Actor-Controlled group.

4. During the acquisition period, participants in the Actor- and Observer-Controlled group would both choose to switch roles following perceived good trials.

It was predicted that participants given control over their practice schedule, would choose to switch roles following perceived good trials, independent of which partner (i.e., Actor or Observer) had control. This prediction was based on the work of Karlinsky and Hodges (2014), who showed that learners with self-control and peers controlling the practice schedule of another learner, both chose to switch between various timing tasks following good trials.

5. During the acquisition period, participants in the Observer-Controlled group would choose to switch roles more frequently than participants in the Actor-Controlled group.

It was predicted the Observer-Controlled group would choose to switch roles more frequently compared to the participants in the Actor-Controlled group, throughout the acquisition phase. This prediction was also based on the work of Karlinsky & Hodges (2014), who showed that peer-schedulers chose to switch between three different motor tasks more frequently than learners with self-control.

6. The dyad groups (i.e., Actor-Controlled, Observer-Controlled, Dyad-Alternate) will commit less minor and major errors throughout the experimental protocol, compared to the individual Control group.

It was predicted throughout the experimental protocol, participants practicing in dyads would commit less minor and major errors in comparison to the Control group. This prediction is based on the observational learning literature showing how the observation of a learning model can aid in error identification and correction processes (Adams, 1986; Lee & White, 1990; Pollock & Lee, 1992). Since all three dyad groups observed their partner practice the task, it was predicted less errors would be committed compared to the participants in the Control group, who were not afforded the opportunity to observe their partner practice.

## 3.0 Methods

### 3.1 Participants

One-hundred individuals (38 males, 61 females, 1 non-binary), aged 18-31 (*M* = 19.4, *SD* = 2.19), from Brock University were recruited to participate in this study. Sample size was calculated using the G*Power program, with an alpha level of 0.05, a power of 0.95, and an effect size of 0.3 (e.g., Karlinsky & Hodges, 2014) (Appendix A). Previous task experience was determined prior to recruitment (i.e., word of mouth) and again within the Demographic Questionnaire (Appendix B). Participants were excluded if they had task experience within the past 10 years or had ever competed in speed cup-stacking at any point. Participants' gender and hand dominance were equally balanced amongst dyads and experiment groups, to the best of our abilities. Participant recruitment took place via electronic announcements through ISAAK/SAKAI in the KINE 2P08 undergraduate class at Brock University, as well as word of mouth throughout the university. Students recruited from the KINE 2P08 class received course credit upon completion of the experimental protocol. After pairing participants to create a dyad, Research Randomizer® was used to randomly assign each dyad to one of four experimental groups: Actor-Controlled (*n* = 24; 12 pairs), Observer-Controlled (*n* = 24; 12 pairs), Dyad-Alternate (*n* = 22; 11 pairs), or Control (*n* = 30; 15 pairs). All participants were informed of the experimental protocol, although naive to the purpose of the experiment, and were required to sign the written informed consent forms prior to their participation in the study. The experimental design received approval from the Research Ethics Board at Brock University.

**3.2 Task and Apparatus**

The motor task for this experiment was a speed cup-stacking sequence, performed in the Motor Skills Acquisition Laboratory at Brock University. The sequence involved participants up-stacking and down-stacking 12 specialized cups (www.speedstacks.ca) within three separate pyramids: 3-cups, 6-cups, 3-cups (Granados & Wulf, 2007). The cups used for this task were smooth to allow for minimum friction and each had three small holes at the top to allow for air to escape quickly when stacking. Furthermore, this task was performed on an official speed cup-stacking mat (StackMats®), to allow for optimal grip of the cups, as well as to provide participants with a pre-defined spatial area in which to perform the motor task (www.speedstacks.ca).

Prior to each trial, the cups were placed face-down in a three-cup tower (i.e., cups stacked upside down, within one another) to the left of the participant, a six-cup tower in the middle, and a three-cup tower on the right (see Appendix C). Underneath each tower of cups was a pre-defined circle printed on the mat, to ensure the starting position of the towers was the same at the beginning of each trial. The participant began with their left index finger on the far-left key of the Chronos® key-pressing device and their right index finger on the far-right key. All other keys on the device were covered with a piece of paper, to avoid pressing the wrong key. Chronos is a multifunctional response and stimulus device, connected by a microswitch to the E-Prime 3.0 customized software. The Chronos device was located on the desk directly in front of the participant, but in between them and the cup-stacking mat (see Appendix D for lab set-up). Once participants removed their fingers from the respective keys, the timer started, and E-Prime began collecting their movement time. Removing their fingers off the buttons was the initiation of phase one (i.e., up-stacking). Participants were instructed to begin the up-stacking phase with the left three-cup pyramid, followed by the middle six-cup pyramid, and ending with the right three-cup pyramid. They were instructed to hold the cups lightly in their fingertips, and alternate between hands when up-stacking. All participants were required to stand while performing the task.

Upon up-stacking all three pyramids, they immediately began phase two: down-stacking. Returning to the three-cup pyramid on the left, the participants were instructed to return the cups to their original starting position, by reversing the pyramids back into towers (see Appendix C). This phase occurred in the same sequence as phase one (i.e., started with the left three-cup pyramid, followed by the middle six-cup pyramid, and ended with the right three-cup pyramid). Participants were instructed to slide the top cup down the side of the others, to allow for smoother and faster movements. Once all three pyramids were back in their original positions, the participant pressed the same keys, again using their left and right index fingers, on the key-pressing device to stop the timer. One practice trial consisted of both the up-stacking and down-stacking phases. The task instructions for this experiment were consistent with previous research using a speed cup-stacking task (Granados & Wulf, 2007; Hebert, 2018; Lessa & Chiviacowsky 2015).

The goal of the task was to complete both phases as quickly and as accurately as possible, while committing the least amount of errors. Errors were classified as either ‘minor’ or ‘major’, at the discretion of the researcher. Minor errors included any form of mistake made by the participant throughout a trial, while the cups remained on the table (i.e., a cup falling onto the table, a cup sliding down onto lower cups in the pyramid, a participant fumbling a cup, etc.). If the participant committed a minor error, they were instructed to correct the error immediately and continue the trial until completion. Major errors included any cup falling off of the table and onto the floor. If the participant committed a major error, they were instructed to stop the timer immediately, and set the cups back into their original position. Trials in which major errors occurred were discarded, with no feedback provided to the learner. The participant was subsequently required to repeat that trial.

**3.3 Experimental Protocol**

The experimental protocol comprised of two consecutive days: day 1 completed individually and in dyads, and day 2 completed individually. Participants were paired with another participant to form a dyad, and randomly assigned to an experimental group. Participants were paired based on hand dominance, gender, and availability. For the Actor-Controlled, Observer-Controlled, and Dyad-Alternate groups, one participant in each dyad was randomly assigned as partner 1 (P1), indicating they would physically perform the motor task (i.e., the Actor) first, during the acquisition phase. The other member of the dyad was assigned as partner 2 (P2) meaning they would complete an observation trial (i.e., the Observer) first, during the acquisition phase. For the Control group, one participant in each dyad was randomly assigned as

P1, meaning they would perform only physical performance trials throughout the acquisition phase. The other participant was assigned as P2, meaning they would only perform observation trials throughout the acquisition phase.

To begin day 1, both members of the dyad were briefly introduced to one another and given individual consent forms to complete. Next, one partner left the laboratory and waited outside, while the other partner completed the pre-test. Before starting the pre-test, the first participant was given the demographic questionnaire (see Appendix B). While they were filling out the questionnaire, the researcher entered the participant number into the customized software. Once the questionnaire was completed, the participant read through a set of task instructions by browsing through the customized E-Prime software. The instruction slides contained information concerning the task, how to properly up-stack and down-stack, what to do if an error is committed, a video of a skilled model performing the task, and a brief description of three required movement techniques. The participant self-determined the amount of time they read through the instruction slides. The participant was allowed to view the video just once and was informed to ask questions if they were unsure of any instructions or the required techniques. A list of the three required movement techniques was posted on the bulletin board, located to the left of the cup-stacking apparatus and above the desktop monitor, such that they could be easily seen from both the Actor and Observer’s viewpoints. Participants could review the techniques at any point throughout the experimental protocol (see Appendix E). The researcher then asked the participant to verbally reiterate the three required movement techniques. Finally, they were notified that a list of five (fictional) dyad movement times was also posted on the bulletin board, for all participants to see (see Appendix F). All dyads were notified of this list and told that it represented the top five dyads thus far in data collection, in regard to their dyad averaged performance on day 2 (i.e., retention). All participants were made aware that the goal was for both partners within their dyad to achieve the fastest times on day 2, such that the average between them and their partner's score, make it on the top five dyad list. The purpose of the top five dyad time list was to induce a collaborative, rather than a competitive, practice environment for all groups. The values within this list were determined based on the actual movement time from an expert performer. Specifically, the times were 10% and 20% greater than and less than an expert's movement time.

Once it was evident the participant fully understood the instructions, they situated themselves behind the cup-stacking apparatus to begin the five pre-test trials. Before they began with the first trial, they were prompted by the software on the desktop screen to "Get ready". The participant was notified that the "Get ready" screen was a prompt for them to place their left index finger on the far-left key and their right index finger on the far-right key, and to depress and hold the keys down. The "Get ready" screen was displayed for 5-seconds. They were instructed to begin the first trial when they saw "Begin when ready" on the screen. The participant was further informed that the task was not a reaction time test, but rather the "Begin when ready" signal was simply a prompt to release the keys when they were ready to begin the trial. Once they lifted their fingers off the keys, the timer started, and the software began collecting the movement time. Once they completed the trial, they depressed the same keys to stop the timer. Upon stopping the timer, a "Trial complete" screen was displayed for 5-seconds, followed by the error screen. The error screen prompted the researcher to enter a "0" if no errors were made, a "1" if a minor error was made, or a "2" if a major error was made. This screen was displayed until the researcher entered a value. If a "2" was entered by the researcher, a "Please repeat trial, press space bar when ready" screen was shown for 5 seconds, before returning to the

“Get ready” screen. If the researcher entered either a “0” or a “1”, the software displayed the “Get ready” screen, to initiate the next pre-test trial. All pre-test trials were completed without external feedback. After completing the five pre-test trials, they left the laboratory and waited outside while their partner entered the laboratory to complete the same pre-test protocol. While the participants waited outside the laboratory, they were given a sudoku puzzle to complete (see Appendix G). They were first asked if they understood how to complete the sudoku. If they were unsure, the researcher briefly described the instructions to the participant. All participants were instructed to work on the puzzle until their partner completed their pre-test, and that the goal was to fill-in as many correct numbers on the puzzle. The pre-test provided baseline movement time scores, as well as enabled the participants to familiarize themselves with the motor task requirements. The order in which partners (i.e., partner 1 or partner 2) performed the pre-test was counterbalanced.

Once both members of the dyad completed the pre-test, the acquisition phase began. While sitting side by side in front of the computer monitor, all dyads were provided with a new set of instructions in which they browsed through together at their self-selected pace. Each experimental group received a different set of instructions, highlighting their individualized protocols. These instructions did not highlight the motor task, but rather explained how the acquisition phase would be carried out regarding their roles for their specific group. Specifically, each group was informed on how the practice session would be conducted, in terms of control over role switching (if applicable). All participants were advised to ask questions if they did not fully understand the protocol. Once both partners verbally reported to the researcher that they understand the protocol, practice began.

For all experimental groups, partner 1 (P1) began standing behind the cup-stacking apparatus. Partner 2 (P2) began sitting in a chair, observing their partner from an objective view (i.e., viewing their partner from the anterior). An objective view requires the observer to reverse two directions of visual information: left and right, as well as front and back. It has been suggested that this reversal of information engages the observer through a deeper level of processing, which may result in a stronger cognitive representation of the skill, compared to viewing a model from the subjective or looking-glass angle (Ishikura & Inomata, 1995). Therefore, it has been suggested that the objective view is the most advantageous to learning (Ishikura & Inomata, 1995) (for visual representation of experimental set-up, see Appendix D).

Prior to the start of each trial, the software would prompt the researcher to enter which participant was physically performing the task (i.e., P1 or P2), To do so, the researcher pressed either 1, indicating P1 was practicing, or 2, indicating P2 was practicing, on the keyboard, located to the right of the Chronos® key pressing device (see Appendix D). Following this, E-Prime presented the "Get ready" screen on the desktop for 5-seconds, identical to the pre-test protocol, prompting the participant to depress and hold the keys down. Next, the "Begin when ready" signal appeared on the screen, also identical to the pre-test protocol, prompting the participant to release the keys when they were ready to begin the trial. Once the participant lifted both index fingers off the keys, the software began recording the movement time. Throughout each trial, a black screen was displayed, such that no concurrent feedback was provided. Once the timer had been stopped, the "Trial complete" screen was displayed for 5-seconds, followed by the error screen. This screen was displayed until the researcher entered either a "0", indicating a no errors were made, a "1" indicating a minor error was made, or a "2" indicating a major error was made. If the researcher entered a "2", a "Please repeat trial, please press space bar when ready" screen would appear for 5 seconds, before returning back to the "Get ready" screen. If the researcher entered either a "0" or a "1", a feedback screen was displayed, in which both partners had a clear view. This feedback screen was provided to all participants, irrespective of their assigned group, and indicated the participant's movement time and their fastest movement time yet (i.e., their "best trial"). After 5-seconds, the remaining number of physical practice trials left for that specific partner, appeared. Up until that point, the experimental protocol remained the same for all four group. Following the feedback screen, the protocol changed, with respect to the experimental group.

First, the Observer-Controlled group followed a turn-taking schedule, such that they switched roles (i.e., Actor and Observer), throughout practice. The Observer, however, had control over when to switch roles. Specifically, when in the Observer role, participants were responsible for controlling their partner's practice schedule. Therefore, at the end of each trial, following the feedback screen, a new screen would appear, prompting the Observer to decide whether or not they wanted to switch roles. This screen displayed: "Observer, do you want your partner to perform another trial, OR do you want them to switch and observe you perform a trial?". Participants had 5-seconds to decide, and then verbally informed the researcher to either "stay" or "switch". All participants were made aware that any form of dialogue between partners was prohibited during the acquisition phase. Thus, the Observer was required to make the decision without collaboration with their partner. Once they informed the researcher of their decision, the researcher would enter which partner was physically practicing the subsequent trial. Each practice trial followed the above protocol. Participants in the Observer-Controlled group were constrained to a minimum of 1 role switch, within each 10-trial block, to ensure turn-taking occurred. Once both partners completed 20 physical practice trials each, they completed the individual, 5-trial, post-test. While one partner completed the post-test, the other waited outside the laboratory and continued to solve their sudoku puzzle. If participants completed the sudoku puzzle during the pre-test, they were provided a second copy of the same puzzle. The post-test followed the same protocol as the pre-test and was executed in the same order (i.e., whichever partner went first in the pre-test, also went first in the post-test). Once both partners completed the post-test, they filled out the *Switching Characteristics Questionnaire*, followed by the *Task Evaluation Questionnaire,* and ended with the partner-related versions of both the *Perceived Competence and Choice Intrinsic Motivation Inventory (IMI) subscales* (see Appendix H). All questionnaires were completed individually, using a pen and paper, while sitting back to back. Upon completion of the questionnaires, participants were free to leave the laboratory for the day. The acquisition phase, for the Observer-Controlled group, took approximately 60 minutes.

The Actor-Controlled group also followed a turn-taking schedule, however the Actor had control over whether they wanted to stay or switch roles (i.e., Actor and Observer) following each trial. Specifically, participants assigned to this group were informed that they were responsible for controlling their own practice schedule. Therefore, after the feedback screen had been displayed for 5-seconds, it changed to a new screen, prompting the Actor to decide whether or not they want to switch roles. This screen displayed: "Actor, do you want to physically perform another trial OR observe on the next trial?". Any dialogue between partners was prohibited during the acquisition phase, such that the Actor had to make the decision without collaboration with their partner. Participants had 5-seconds to decide, before informing the researcher of their decision. The researcher would then enter which participant was physically performing the subsequent trial. Each practice trial followed the above protocol. Participants in the Actor-Controlled group were constrained to a minimum of 1 role switch, within each 10-trial block. Once both partners completed 20 physical practice trials each, they completed the individual, 5-trial, post-test. While one partner completed the post-test, the other waited outside the laboratory and continued to solve their sudoku puzzle. If participants completed the sudoku puzzle during the pre-test, they were provided a second copy of the same puzzle. The post-test followed the same protocol as the pre-test and was executed in the same order (i.e., whichever partner went first in the pre-test, also went first in the post-test). Once both partners completed the post-test, they both filled out the *Switching Characteristics Questionnaire*, followed by the *Task Evaluation Questionnaire,* and ending with the partner-related versions of both the *Perceived Competence and Choice IMI subscales* (see Appendix H). All questionnaires were completed individually, using a pen and paper, while sitting back to back. Upon completion of the questionnaires, participants were free to leave the laboratory for the day. The acquisition phase, for the Actor-Controlled group, took approximately 60 minutes.

For the Dyad-Alternate group, neither partner had control over whether they wanted to stay or switch their respective roles (i.e., Actor or Observer). Rather, they followed a fixed practice schedule, in which they switched roles after each trial. Therefore, after the feedback screen had been displayed for 5-seconds, a new screen displayed “Please switch roles”, initiating the Actor to become the Observer, and the Observer to become the Actor. Following this screen, E-Prime displayed a prompt for the researcher to enter which partner was physically practicing the subsequent trial (i.e., P1 or P2). The participants were informed that any form of dialogue between partners was prohibited during the acquisition phase. Once both partners completed 20 physical practice trials each, they completed the individual, 5-trial, post-test. While one partner completed the post-test, the other waited outside the laboratory and continued to solve their sudoku puzzle. If participants completed the sudoku puzzle during the pre-test, they were provided a second copy of the same puzzle. The post-test followed the same protocol as the pre-test and was executed in the same order (i.e., whichever partner went first in the pre-test, also went first in the post-test). Once both partners completed the post-test, they both filled out the *Switching Characteristics Questionnaire*, followed by the *Task Evaluation Questionnaire*, and ended with the partner-related versions of both the *Perceive Competence and Choice IMI subscales* (see Appendix H). All questionnaires were completed individually, using a pen and paper, while sitting back to back. Upon completion of the questionnaires, participants were free to leave the laboratory for the day. The acquisition phase, for the Dyad-Alternate group, took approximately 60 minutes.

For the Control group, neither partner had control over whether they want to stay or switch their respective roles (i.e., Actor or Observer). Rather, they followed a fixed practice schedule, in which partner 1 performed all 40 physical practice trials consecutively, while partner 2 observed. The purpose of the Actor was to examine a traditional individual practice protocol, while the purpose of the Observer was to control for the presence of a partner throughout individual practice (Hamilton & Lind, 2016). Therefore, after the feedback screen was displayed for 5-seconds, a new screen showed “Please remain in your respective roles” for 5-seconds. Following this, the program prompted the researcher to enter which partner was practicing (i.e., always P1), followed by the “get ready” screen to initiate the next trial. The participants were informed that any form of dialogue between partners was prohibited during the acquisition phase. After P1 completed all 40 physical practice trials, participants completed the individual, 5-trial, post-test. While one partner completed the post-test, the other waited outside the laboratory and continued to solve their sudoku puzzle. If participants completed the sudoku puzzle during the pre-test, they were provided a second copy of the same puzzle. The post-test followed the same protocol as the pre-test and was executed in the same order (i.e., whichever partner went first in the pre-test, also went first in the post-test). Once both partners completed the post-test, they both filled out the adapted *Switching Characteristics Questionnaire* and the *Task Evaluation Questionnaire*. In addition, P2 also filled out the partner-related versions of both the *Perceived Competence* and *Choice IMI subscales* (see Appendix H). All questionnaires were completed individually, using a pen and paper, while sitting back to back. Upon completion of the questionnaires, the participants were free to leave the laboratory for the day. The acquisition phase, for the Control group, took approximately 60 minutes.

All participants were required to return to the laboratory individually, approximately 24 hours following the end of the acquisition phase, to complete both the retention and transfer tests. The retention and transfer tests were completed by all participants, individually, with the same protocol, regardless of their assigned group. The retention test included 2 warm-up trials (Adams, 1952; Hebert, 2018), followed by 5 consecutive physical performance trials of the same cup-stacking sequence practiced in the acquisition phase (Granados & Wulf, 2007). The retention test also included the same goal of performing the task as quickly and as accurately as possible. The purpose of the retention test was to examine the relative permanence of the performance achieved in acquisition, and thus the extent to which the motor skill was retained over time (Kantak & Winstein, 2012). The retention trials followed the same experimental protocol as the acquisition trials, however, participants performed the retention test in the absence of partner. In addition, participants did not receive feedback in regard to their movement time. Participants began Day 2 with a new set of instructions, presented on the customized software, explaining how the protocol was going to be carried out. Once they finished reading the instructions, the program displayed the “Get ready” screen for 5-seconds, followed by the

"Begin when ready" screen. Once the participant lifted their index fingers off the keys, the black screen appeared, signifying to the participant to begin their movements. Similar to acquisition, participants depressed the designated Chronos keys to end the trial. After the timer had been stopped, the "Trial complete" screen was displayed for 5-seconds, before changing to the error screen. If the trial included a major error, the researcher entered a "2", which lead to the "Please repeat trial. Press space bar when ready" screen. Once the cups were back in the starting position, the researcher would press the space bar to initiate the "get ready" screen to repeat the trial. If the trial included a minor error, the researcher entered a "1", and if the trial included no error, the researcher entered a "0". Both of which lead to the "get ready" screen, initiating the subsequent retention trial.

Following the completion of the 5 retention trials, participants were required to physically perform another 5 trials, but of a new cup-stacking sequence, for the transfer test. The sequence consisted of one 10-cup pyramid, which participants were instructed to perform as quickly and as accurately as possible (Appendix I). The participants read through a new set of instructions by browsing through a series of slides presented on the customized software. The participants were instructed to utilize the same movement techniques explained at the beginning of the acquisition phase. The purpose of the transfer test was to assess the adaptability of the motor task learned throughout acquisition, thus providing information concerning the generalizability of the motor memory (Kantak & Winstein, 2012). The transfer test followed a similar experimental protocol to the retention test, such that participants performed the transfer test in the absence of their partner and external feedback. The customized software followed the same course for the transfer test, as it did for the retention test. Prior to leaving the laboratory, all participants completed the paired practice experience questionnaire, which differed based on their assigned group (see Appendix H). Day 2 of the experimental protocol took approximately 15 minutes. A visual overview of the entire experimental protocol for this study can be found in Appendix J.

### 3.4 Data Analysis

Based on the research question and purposes of this thesis, all statistical analyses involving the Control group included data from partner 1, exclusively. The data from the partner 2s in the Control group were not included in any analyses, as the Actor (i.e., partner 1) was the primary focus of the Control group.

#### 3.4.1 Movement Time

To determine if there were any statistical differences in movement time between the experimental groups prior to the experimental protocol, a 4 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate, Control) x 1 Block (Pre-test) one-way analysis of variance (ANOVA) was performed.

The movement time scores from the acquisition phase were first organized into 4 blocks of 10 trials and examined per dyad. Specifically, the physical practice trials were equated amongst dyads and analyzed per dyad because practice was confounded by observation trials in both the Actor- and Observer-Controlled groups. For example, in the first block, a participant in the Dyad-Alternate group would have physically performed 5 trials and observed 5 trials, whereas a participant in the Actor-Controlled group may have only physically performed 1 trial and observed 9 trials. Additionally, participants in the Actor-Controlled, Observer-Controlled, and Dyad-Alternate groups performed 20 trials each, whereas participants in the Control group performed 40 trials each, and thus the number of individual participant trials are not equated between groups. Therefore, the acquisition data should consequently be interpreted with caution. Accordingly, to determine if there were significant differences in movement time scores throughout the acquisition phase, a 4 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate, Control) x 4 Block (One, Two, Three, Four) repeated measures ANOVA was performed.

The movement time scores from the acquisition phase were further organized into 4 blocks of 5 trials for the Actor-Controlled, Observer-Controlled, and Dyad-Alternate groups, and 4 blocks of 10 trials for the Control group and analyzed per participant. These physical practice trials were equated within each dyad. As previously mentioned, due to the confounding observation trials, as well as the unequal number of trials between groups, the acquisition data should be interpreted with caution. Therefore, to determine if there were any statistical differences in movement time, per participant, throughout the acquisition phase, a 4 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate, Control) x 4 Block (One, Two, Three, Four) ANOVA with repeated measures on the final factor, was conducted.

To determine if there were any statistical learning differences with regards to movement time, a 4 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate, Control) x 3 Time (Pre-test, Post-test, Retention) ANOVA with repeated measures on the last factor, was conducted. A 4 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate, Control) x 1 Block (Transfer) ANOVA was used to examine movement time scores on the transfer test.

**3.4.2 Switching Frequency**

To determine if there were any significant differences in the frequency of role-switching throughout the acquisition phase between the Actor-Controlled and Observer-Controlled groups, the acquisition data were organized into 4 blocks of 10 trials, for each dyad. The number of switches within each 10-trial block was recorded. These data were analyzed using a 2 Group (Actor-Controlled, Observer-Controlled) x 4 Block (one, two, three, four) ANOVA with repeated measures on the final factor.

**3.4.2.1 Switching Frequency and Movement Time Correlations**

To determine if there were any statistically significant correlations between the frequency of switching and movement time, separate Pearson Correlation tests were run for the Actor- and Observer-Controlled groups for the acquisition phase, post-test, retention test, and transfer test.

**3.4.3 Switching Trial Type**

To determine if there were any statistical differences between the types of trials the Actor-Controlled and Observer-Controlled groups chose to switch roles after (i.e., after perceived good, after perceived bad, after perceived bad and good equally, random, other), data from the acquisition phase were separated into “switch” and “non-switch” trials. The “switch” trials were classified as the trials in which participants chose to subsequently switch roles with their partner, while the “non-switch” trials were the trials preceding a switch trial (i.e., switch - 1). Participant’s mean “switch” and “non-switch” scores were then analyzed using a 2 Group (Actor-Controlled, Observer-Controlled) x 2 Trial Type (switch, switch - 1) ANOVA with repeated measures on the final factor.

**3.4.4 Performance Errors**

The number of minor and major errors committed throughout the acquisition phase was analyzed using separate 4 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate, Control) x 4 Block (One, Two, Three, Four) repeated measures ANOVAs. The number of minor and major errors committed in the pre-test, post-test and retention test was analyzed using separate 4 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate, Control) x 3 Time

(Pre-test, Post-test, Retention) ANOVAs with repeated measures on the last factor. The number of minor and major errors committed on the transfer test was analyzed using a separate univariate ANOVA with Group as the between factor.

### 3.4.5 Switching Characteristics Questionnaire

Data from the *Switching Characteristics Questionnaire* were presented as descriptive statistics (i.e., Means and Standard Deviations).

### 3.4.6 Task Evaluation Questionnaire

Data from the *Task Evaluation Questionnaire* were separated into each of the four subscales of the IMI (i.e., interest/enjoyment, pressure/tension, competence, choice). Participants' scores from each subscale were averaged and submitted to separate univariate ANOVAs with Group as the between variable. For the three dyad groups, to analyze if there were significant differences between the participant's perceived competence compared to their partner's competence, a 3 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate) x 2 Competence (Own, Partner) repeated measures ANOVA was conducted. Lastly, for the three dyad groups, to examine if there were significant differences between the participant's perceived choice in performing the task compared to their partner's choice, a 3 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate) x 2 Choice (Own, Partner) repeated measures ANOVA was performed.

### 3.4.7 Paired Practice Experience Questionnaire

Responses from the *Paired Practice Experience Questionnaire* were analyzed using separate univariate ANOVAs, based on group means for each question. All questions were answered via a scale from 1 to 7 (1= "not at all true", 4= "somewhat true", 7= "very true"). Some questions were asked to all groups, while other questions were only asked to select groups. In addition, the wording of some questions was modified based on the respective group (see Table 12 for visual representation).

All statistical analyses were conducted using IBM SPSS Statistics (Version 25). The alpha level was set at $p \leq .05$ for all statistical analyses, and Tukey's honest significant difference post hoc was used to analyze any statistically significant interactions and effects. Partial eta squared ($\eta^2$) was used as a measure of effect size when $p < .05$, and the Greenhouse-Geisser adjustment was used if the assumption of sphericity was violated.

## 4.0 Results

### 4.1 Movement Time

#### 4.1.1 Pre-Test

The pre-test data were analyzed using a 4 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate, Control) x 1 Block (Pre-test) ANOVA. The results showed no main effect for Group, $F(3, 84) = 1.09$, $p = .360$ (see Table 1; Figure 1).

#### 4.1.2 Acquisition – Physical Practice Equated Amongst Dyads (Analyzed Per Dyad)

The acquisition data were first organized into 4 blocks of 10 trials and analyzed per dyad using a 4 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate, Control) x 4 Block (One, Two, Three, Four) repeated measures ANOVA. There was a significant main effect for Block, $F(3, 138) = 79.6$, $p < .001$, $\eta_p{}^2 = .634$. Block one ($M$ = 11161.9 ms, $SD$ = 186.0) was significantly slower than block two ($M$ = 10354.0 ms, $SD$ = 139.4), block three ($M$ = 9787.1 ms, $SD$ = 141.0), and block four ($M$ = 9441.4 ms, $SD$ = 138.7). Block two was also significantly slower than block three and block four, and block three was significant slower than block four. There was no significant main effect for Group, $F(3, 46) = 2.36$, $p = .084$, nor a Group x Block interaction, $F(9, 138) = 1.22$, $p = .289$ (see Table 2; Figure 1).

### 4.1.3 Acquisition – Physical Practice Equated Within Dyads (Analyzed Per Participant)

The acquisition data were further organized in 4 blocks of 5 trials for the Actor-Controlled, Observer-Controlled, and Dyad-Alternate groups, and 4 blocks of 10 trials for the Control group. These data were analyzed per participant, using a 4 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate, Control) x 4 Block (One, Two, Three, Four) RM-ANOVA. Mauchly's Test of Sphericity was violated, and therefore the Greenhouse-Geisser correction was used during the analyses. The results showed a significant main effect for Block, $F(2.6, 208.9) = 73.1$, $p < .001$, $\eta_p{}^2 = .474$. There was no significant main effect for Group, $F(3, 81) = 2.5$, $p = .065$, nor a Group x Block interaction, $F(7.7, 208.9) = 1.17$, $p = .320$. The post-hoc test revealed that block one (*M* = 11138.6 ms, *SD* = 180.9) was significant slower than block two (*M* = 10335.3 ms, *SD* = 132.8), block three (*M* = 9820.7 ms, *SD* = 140.9), and block four (*M* = 9456.0 ms, *SD* = 128.2). block two was also slower than block three and block four, and block three was also slower than block four (see Table 3; Figure 2)

### 4.1.4 Pre, Post, Retention

Mauchly's Test of Sphericity was violated, and therefore the Greenhouse-Geisser correction was used during the analyses. The 4 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate, Control) x 3 Time (Pre, Post, Retention) ANOVA with repeated measures on the final factor, showed a significant main effect for Time, $F(1.37, 111.1) = 440.9$, $p < .001$, $\eta_p{}^2 = .845$. The was no significant main effect for Group, $F(3, 81) = 1.37$, $p = .259$, nor a Group x Time interaction, $F(4.11, 111.1) = 0.592$, $p = .674$. The Tukey post-hoc test showed that movement time scores were slower on the pre-test (*M* = 14038.5 ms, *SD* = 250.8) compared to the post-test (*M* = 9494.5 ms, *SD* = 122.9) and the retention test (*M* = 9095.9 ms, *SD* = 116.3).

The post-hoc also showed that movement time scores were slower on the post-test compared to the retention test (see Table 1; Figure 1).

#### 4.1.5 Transfer

Movement time scores on the transfer test were analyzed using a one-way ANOVA. This test revealed no significant differences between the groups, $F(3, 84) = .794$, $p = .501$ (see Table 1; Figure 1).

### 4.2 Switching Frequency

The acquisition data were organized into 4 blocks of 10 trials. The 2 Group (Actor-Controlled, Observer-Controlled) x 4 Block (One, Two, Three, Four) repeated measures ANOVA revealed a significant main effect for Group, $F(1, 22) = 5.11$, $p = .034$, $\eta_p{}^2 = .188$. There was no main effect for Block, $F(3, 66) = 2.08$, $p = .111$, nor a Group x Block interaction, $F(3, 66) = 0.873$, $p = .459$. The Observer-Controlled group switched more frequently ($M = 1.94$, $SD = 0.091$), than the Actor-Controlled group ($M = 1.65$, $SD = .091$) (see Table 4).

#### 4.2.1 Switching Frequency and Movement Time Correlations

##### 4.2.1.1 Actor-Controlled

###### 4.2.1.1.1 Acquisition

The results of the Pearson correlation for the Actor-Controlled group in the acquisition phase showed a significant negative correlation between switching frequency and movement time, ($r(23) = -.435$, $p = .034$) (see Table 13; Figure 5).

###### 4.2.1.1.2 Post-Test

The results of the Pearson correlation for the Actor-Controlled group on the post-test showed no significant correlation between switching frequency and movement time, ($r(23) = -.120$, $p = .575$) (see Table 13; Figure 7).

#### 4.2.1.1.3 Retention

The results of the Pearson correlation for the Actor-Controlled group on the retention test showed no significant correlation between switching frequency and movement time, ($r(23) = -.287$, $p = .173$) (see Table 13; Figure 9).

#### 4.2.1.1.4 Transfer

The results of the Pearson correlation for the Actor-Controlled group on the transfer test showed no significant correlation between switching frequency and movement time, ($r(23) = -.282$, $p = .181$) (see Table 13; Figure 11).

### 4.2.1.2 Observer-Controlled

#### 4.2.1.2.1 Acquisition

The results of the Pearson correlation for the Observer-Controlled group in the acquisition phase showed no significant correlation between switching frequency and movement time, ($r(23) = .118$, $p = .584$) (see Table 13; Figure 6).

#### 4.2.1.2.2 Post-Test

The results of the Pearson correlation for the Observer-Controlled group on the post-test showed no significant correlation between switching frequency and movement time, ($r(23) = -.100$, $p = .641$) (see Table 13; Figure 8).

#### 4.2.1.2.3 Retention

The results of the Pearson correlation for the Observer-Controlled group on the retention test showed no significant correlation between switching frequency and movement time, ($r(23) = .108$, $p = .616$) (see Table 13; Figure 10).

#### 4.2.1.2.4 Transfer

The results of the Pearson correlation for the Observer-Controlled group on the transfer test showed no significant correlation between switching frequency and movement time, (r(23) = -.107, p = .618) (see Table 13; Figure 12).

## 4.3 Switching Trial Type

The 2 Group (Actor-Controlled, Observer-Controlled) x 2 Trial Type (Switch, Switch -1) repeated measures ANOVA revealed no significant main effect for Trial Type, $F(1, 46) = 1.04$, $p = .312$, or Group, $F(1, 46) = 0.006$, $p = .936$. The Group x Trial Type interaction was also not statistically significant, $F(1, 46) = 0.007$, $p = .934$. See Table 5 for mean movement time scores on switch and non-switch trials.

## 4.4 Performance Errors

### 4.4.1 Minor Errors

#### 4.4.1.1 Acquisition

Mauchly's Test of Sphericity was violated, and therefore the Greenhouse-Geisser correction was used during the analyses. The number of minor errors committed throughout the acquisition phase was examined per dyad and analyzed using a 4 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate, Control) x 4 Block (One, Two, Three, Four) RM-ANOVA. There was no main effect for Block, $F(2.56, 117.9) = 0.107$, $p = .956$, Group, $F(3, 46) = 0.362$, $p = .780$, or Group x Block interaction, $F(7.7, 117.9) = 0.971$, $p = .460$ (see Table 9; Figure 3).

#### 4.4.1.2 Pre-, Post-, Retention

The number of minor errors committed throughout the protocol was analyzed using a 4 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate, Control) x 3 Time (Pre, Post, Retention) ANOVA with repeated measures on the final factor. The main effect for Time was not statistically significant, $F(2, 162) = 0.887$, $p = .414$. The main effect for Group was also not statistically significant, $F(3, 81) = 1.31$, $p = .277$, nor was the Group x Time interaction, $F(6, 162) = 0.430$, $p = .858$ (see Table 10; Figure 3).

#### 4.4.1.3 Transfer

The number of minor errors committed during the transfer test was analyzed using a one-way ANOVA. This test revealed no statistically significant differences between groups, $F(3, 84) = 1.85$, $p = .132$ (see Table 10; Figure 3).

### 4.4.2 Major Errors

#### 4.4.2.1 Acquisition

The number of major errors committed throughout the acquisition phase was examined per dyad and analyzed using a 4 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate, Control) x 4 Block (One, Two, Three, Four) RM-ANOVA. There was no main effect for Block, $F(3, 138) = 0.487$, $p = .692$, Group, $F(3, 46) = 1.02$, $p = .391$, or Group x Block interaction, $F(9, 138) = 1.57$, $p = .130$ (see Table 9; Figure 4).

#### 4.4.2.2 Pre-, Post-, Retention

The number of major errors committed throughout the protocol was analyzed using a 4 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate, Control) x 3 Time (Pre, Post, Retention) ANOVA with repeated measures on the final factor. The analysis showed a statistically significant main effect for Time, $F(2, 162) = 3.58$, $p = .030$, $\eta_{p^2} = .042$. There was no main effect for Group, $F(2, 678) = 0.088$, $p = .966$, and the Group x Time interaction was not statistically significant, $F(6, 162) = 1.25$, $p = .282$. The Tukey post hoc test showed more major errors were committed in the pre-test ($M = .435$, $SD = .074$) compared to the retention test ($M =$

.188, *SD* = .045). The post hoc also revealed that there were no significant differences in the number of major errors committed in pre-test and the post-test (*M* =.323, *SD* =.071), and the post-test and retention test (see Table 10; Figure 4).

#### 4.4.2.3 Transfer

The number of major errors committed during the transfer test was analyzed using a one-way ANOVA. This test revealed no statistically significant difference between groups, $F(3, 84) = 0.461$, $p = .711$ (see Table 10; Figure 4).

## 4.5 Self-report Data

### 4.5.1 Switching Characteristics Questionnaire

Data from the questionnaire showed that when their partner was in control of the practice schedule, 22 participants (91.7%) in the Actor-Controlled group, as well as 22 participants (91.7%) in the Observer-Controlled group, believed that their partner switched roles after the appropriate trials. The two remaining participants (8.33%) in the Actor-Controlled group both stated they would have preferred for their partner to switch roles following perceived bad trials. One of the remaining participants (4.17%) in the Observer-Controlled group stated they would have preferred for their partner to switch roles randomly, while the last remaining participant (4.17%) in the Observer-Controlled group would have preferred for their partner to switch roles following perceived good and bad trials equally. When asked to rate how well their partner's role switching facilitated their learning (1 = "did not facilitate my learning at all", 4 = "somewhat facilitated my learning", 7 = "completely facilitated my learning"), the Actor-Controlled group reported an average score of 4.2/7 (SD = 1.17), while the Observer-Controlled group reported an average score of 4.7/7 (SD = 1.37). See Table 6.

When in control of their own practice schedule (i.e., Actor-Controlled group), 3 (12.5%) participants reported they switched roles after perceived good trials, 5 (20.8%) reported they switched roles after perceived bad trials, 7 (29.2%) reported they switched roles after perceived good and bad trials equally, 6 (25%) reported they switched roles randomly, and 3 (12.5%) reported there was a different reason for switching roles. When in control of their partner's practice schedule (i.e., Observer-Controlled group), 7 (29.2%) participants reported they switched roles after perceived good trials, 5 (20.8%) reported after perceived bad trials, 6 (25%) reported they switched roles after perceived good and bad trials equally, 4 (16.7%) reported they switched roles randomly, and 2 (8.2%) reported a different reason for switching roles.

When in control of their own practice schedule (i.e., Actor-Controlled group), 10 (41.7%) participants reported they did not switch roles after perceived good trials, 4 (16.7%) reported they did not switch roles after perceived bad trials, 6 (25%) reported they did not switch randomly, and 4 (16.7%) reported a different reason for not switching roles (see Table 5). When in control of their partner's practice schedule (i.e., Observer-Controlled group), 11 (45.8%) participants reported they did not switch roles after perceived good trials, 6 (25%) reported they did not switch roles after perceived bad trials, 3 (12.5%) reported they did not switch roles following perceived good and bad trials equally, 3 (12.5%) reported they did not switch randomly, and 1 (4.2%) reported a different reason for not switching roles (see Table 6).

The participants in the Dyad-Alternate group were asked to rate how well switching roles after each practice trial facilitated their learning (1 = "did not facilitate my learning at all", 4 = "somewhat facilitated my learning", 7 = "completely facilitated my learning"). On average, the group reported a score of 4.3/7 (SD = 1.39). These participants were also asked if they would have preferred to have control over when to switch roles with their partner**.** The self-report data revealed that 11 (50%) participants would have preferred to have control over the role switching, while the other 11 (50%) were content with not having control. Those who reported they would have preferred to have control, were subsequently asked when they would have switched roles. Six (54.5%) of those participants reported they would have switched roles following perceived good trial, 3 (27.3%) reported they would have switched roles following perceived bad trials, and 2 (18.2%) reported they would have switched roles following perceived good and bad trials equally (see Table 7).

Data from the Control group includes partner 1 data, only. Participants in the Control group were asked to rate how well switching roles would have facilitated their learning (1 = "would not facilitate my learning at all", 4 = "would somewhat facilitate my learning", 7 = "would completely facilitate my learning"). Results from the questionnaire revealed an average score of 4.9/7 (SD = 1.21). The same participants were also asked if they would have liked to have control over when to switch roles with their partner, had they had the opportunity. Results showed that 7 (46.7%) participants reported they would have liked to have control, while the other 8 (53.3%) participants reported they would not have liked to have control. Of the 7 participants who would have like to have control over role switching, 1 (14.3%) reported they would have liked to switch roles following perceived good trials, 2 (28.6%) reported they would have liked to switch roles following perceived bad trials, 3 (42.9%) reported they would have liked to switch following perceived good and bad trials equally, and finally 1 (14.3%) reported they would have liked to switch roles randomly (see Table 8).

### 4.5.2 Intrinsic Motivation Inventory

#### 4.5.2.1 Task Evaluation Questionnaire

The univariate ANOVAs revealed no significant differences between groups for the interest/enjoyment subscale, $F(3, 81) = 1.49$, $p = .224$, pressure/tension subscale, $F(3, 81) = 0.805$, $p = .495$, competence subscale, $F(3, 81) = 0.242$, $p = .867$, or choice subscale, $F(3, 81) = 1.79$ $p = .155$ (see Table 11).

#### 4.5.2.2 Partner-Related Competence and Choice

For the dyad groups, a 3 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate) x 2 Competence Type (Own, Partner) repeated measures ANOVA showed a main effect for Competence type, $F(1, 67) = 33.05$, $p < .001$, $\eta_p{}^2 = .330$. There was no main effect for Group, $F(2, 67) = .286$, $p = .752$, nor a Group x Competence Type interaction, $F(2, 67) = 1.02$, $p = .365$. The participants rated their partner's competence ($M = 4.59$, $SD = .092$) as greater than their own ($M = 3.73$, $SD = .130$) (see Table 11).

The 3 Group (Actor-Controlled, Observer-Controlled, Dyad-Alternate) x 2 Choice Type (Own, Partner) repeated measures ANOVA showed a main effect for Choice Type $F(1, 67) = 99.92$, $p < .001$, $\eta_p{}^2 = .599$. There was no main effect for Group, $F(2, 67) = 1.11$, $p = .336$, nor a Group x Choice Type interaction, $F(2, 67) = 2.32$, $p = 0.107$. The participants perceived they had more choice in performing the task ($M = 5.39$, $SD = 1.19$), compared to their partners ($M = 3.26$, $SD = .806$) (see Table 11).

### 4.5.3 Paired Practice Experience Questionnaire

Participants responded to questions regarding their paired practice experience, on a scale from 1 to 7 (1= "not at all true", 4= "somewhat true", 7= "very true"). Observing a partner's practice was perceived as somewhat helpful by the Actor-Controlled ($M = 4.83$, $SD = 1.66$), Observer-Controlled (*M* = 5.05, *SD* = 1.49), and Dyad-Alternate (*M* = 4.68, *SD* = 1.59) groups, but not as a function of Group, *F*(2, 66) = .298, *p* = .744. Observing a partner's practice was also perceived as slightly interfering by the Actor-Controlled (*M* = 3.25, *SD* = 1.87), Observer-Controlled (*M* = 2.43, *SD* = 1.27), and Dyad-Alternate (*M* = 3.09, *SD* = 1.48) groups, but there was no main effect for Group *F*(2, 66) = 1.77, *p* = .179. There was also no main effect for Group between the Actor-Controlled (*M* = 4.79, *SD* = 1.67), Observer-Controlled (*M* = 3.87, *SD* = 1.94), Dyad-Alternate (*M* = 4.23, *SD* = 1.88), or Control (partner 1s) (*M* = 4.67, *SD* = 1.59) groups, in wanting to perform faster than their partner on Day 2, *F*(3,80) = 1.23, *p* = .304. Participants in the Actor-Controlled (*M* = 4.58, *SD* = 1.47) and Observer-Controlled (*M* = 4.57, *SD* = 1.31) groups both reported that they controlled the practice schedule to benefit their own learning, to a certain extent, albeit there were no differences between the two groups, *F*(1, 45) = .002, *p* = .965. Participants were also asked to report the extent to which they controlled the practice schedule to benefit their partner's learning. Statistically significant differences were found between the Actor-Controlled (*M* = 3.67, *SD* = 1.44) and Observer-Controlled (*M* = 4.78, *SD* = 1.73) groups, with the Observer-Controlled group reporting a higher value *F*(1, 45) = 5.81, *p* = .020, $\eta_{p^2}$ = .114. The Actor-Controlled (*M* = 5.33, *SD* = 1.74), Observer-Controlled (*M* = 5.65, *SD* = 1.03), Dyad-Alternate (*M* = 5.41, *SD* = 1.65), and Control (partner 1s) (*M* = 5.53, *SD* = 1.30) groups all reported that they wanted to perform faster than the top 5 pairs listed in laboratory, however there were no significant differences between the groups, *F*(3, 80) = .207, *p* = .891. Finally, the Actor-Controlled (*M* = 4.13, *SD* = 1.99), Observer-Controlled (*M* = 3.17, *SD* = 1.99), Dyad-Alternate (*M* = 4.36, *SD* = 1.92), and Control (partner 1s) (*M* = 3.73, *SD* = 1.94) groups all reported that they "somewhat" would have preferred to practice alone, however there were no statistically significant differences between the four groups, $F(3, 80) = 1.59$, $p = .199$. For a visual representation of the questions asked to each group, see Table 12.

## 5.0 Discussion

### 5.1 Movement Time

The first purpose of the present study was to determine whether providing control over role-switching to one member of a dyad (i.e., either the Actor or the Observer) would differentially impact the acquisition of a novel motor skill, compared to a traditional turn-taking dyad and individual practice (i.e., pure physical practice). The second purpose of the present study was to examine the switching strategies adopted by the Actor- and Observer-Controlled groups, throughout the acquisition phase.

It was predicted the Actor- and Observer-Controlled groups would perform superiorly (i.e., faster movement time scores) on the post-, retention, and transfer tests, compared to the Control group, who experienced pure physical practice. As previously discussed, this prediction was based on two separate lines of research. First, previous research has suggested that traditional alternating dyad practice (i.e., switching roles after each practice trial) is as effective as individual practice, in terms of movement time scores for the learning of a speed cup-stacking task (Granados & Wulf, 2007). In fact, there is evidence, albeit very limited, to suggest that alternating dyad practice can be more effective than individual practice (Shea et al., 1999). Specifically, in 1999, Shea and colleagues showed that participants who practiced a complex balance task in alternating dyads demonstrated lower RMSEs compared to participants who practiced alone. Furthermore, prediction one was based on research showing that providing learners with control (i.e., either self- or peer-control) over certain practice variables, enhances motor learning compared to yoked or experimenter-controlled conditions (Karlinsky & Hodges, 2014; Keetch & Lee, 2007; McRae et al., 2015; Patterson et al., 2019; Wu & Magill, 2011). In addition, there is evidence to show the benefits of peer- and self-controlled practice for the learning of different timing tasks, such as sequential key-pressing (Aiken et al., 2020; McRae et al., 2015; Patterson et al., 2019; Wu & Magill, 2011), pattern drawing (Keetch & Lee, 2007), and speed cup-stacking (Lessa & Chiviacowsky, 2015). Based on both lines of research collectively, it was expected the additive component of having control over role-switching (i.e., Actor- and Observer-Controlled groups) within a dyad would provide participants with enhanced skill acquisition, demonstrated through faster movement time scores, compared to pure physical practice with no control. Prediction one was not supported, as the results of the present study showed no statistically significant differences between the dyad groups (i.e., Actor- and Observer-Controlled) and the Control group on the post-, retention, and transfer tests for movement time.

However, the movement time results do support the notion of dyad practice facilitating practice efficiency for skill acquisition. Participants who practiced in dyads, independent of control, demonstrated relatively similar movement times compared to participants who practice individually (i.e., Control), who experienced twice as much physical practice with the task (40 trials vs. 20 trials). Thus, training efficacy was supported such that two participants (i.e., those who practiced in a dyad) showed comparable movement time scores to those who practiced individually, but within the same time frame. These results are consistent with previous research examining surgical skills training, whereby training efficiency was supported for bronchoscopy (Bjerrum et al., 2014), lumbar puncture (Shanks et al., 2013), laparoscopic (Bao et al., 2019) and coronary angiography (Räder et al., 2014) simulation-based tasks. In addition, the results support the findings from Karlinsky and Hodges (2018), who identified that alternating dyad practice was an efficient alternative to individual practice, for the learning of a complex balance task.

One reason underlying the efficiency of dyad practice, is likely the opportunity to observe a partner practice. In fact, previous research has shown that observing a learning model (i.e., a partner) facilitates motor learning on various timing tasks (Black & Wright, 2000; Blandin, Lhuisset, Proteau, 1999; Blandin & Proteau, 2000; Pollock & Lee, 1992; Rohbanfard & Proteau, 2011, Experiment 1). In 1986, Adams examined the effects of observing an unskilled model for the acquisition of a novel movement timing task. It was found that when the observers were provided the model's KR, substantial learning effects were seen (Adams, 1986). Adams, along with other researchers, have suggested that learning models engage the observer in problem-solving activities similar to those experienced during physical practice (Adams, 1986; Lee & White, 1990; Shea et al., 2000). Given the task for the present study required the complex coordination of two-handed movements, the observers could have observed the trial and error processes experienced by their partner, and subsequently avoided making the same errors on their own physical practice trials. In this context, the dyad participants could have utilized their partner's performance as a means to solve the cognitive portion of the task, and therefore only half as many physical practice trials were required to achieve similar levels of performance, compared to the Control group. Based on the present results, along with the previously mentioned dyad and surgical skills training literature, the benefits associated with observational learning suggests that interspersing physical practice with observation of a partner within a dyad makes for efficient practice, as participants seemingly learned from performing and observing the motor task. Overall, finding that learning in a dyad occurred, independent of control, is a novel contribution to the motor learning literature, and extends our knowledge of the utility and flexibility of dyad practice.

Upon the completion of practice, it was predicted that both the Actor- and Observer-Controlled groups would perform faster than the traditional turn-taking (i.e., Dyad-Alternate) group, on the post-, retention, and transfer tests. This prediction was based on the self-control and peer-control literature examining various timing tasks. This line of research suggests that providing control to the learner or the peer over KR feedback schedules (Carter et al., 2014; McRae et al., 2015; Patterson et al., 2019) and task-switching for multi-task learning (Karlinsky & Hodges, 2014) leads to greater skill acquisition compared to experimenter-controlled or yoked practice schedules. The movement times of the experimental groups on the post-, retention, and transfer tests did not support this prediction. The results showed no statistically significant differences between the Actor- and Observer-Controlled groups compared to the Dyad-Alternate group. An explanation for the lack of group differences upon completion of the acquisition period is associated with the practice schedules chosen by the participants in the Actor- and Observer-Controlled groups. For instance, participants in the Actor-Controlled group were instructed they were responsible for controlling their own practice schedule. In fact, the Actor-Controlled group self-reported that they chose to schedule their practice (i.e., role-switching) to benefit their own learning ($M$ = 4.58, $SD$ = 1.47), compared to their partner's learning ($M$ = 3.67, $SD$ = 1.44). These results show participants in the Actor-Controlled group followed the instructions they were given. Similarly, participants in the Observer-Controlled group were told they were responsible for controlling their partner's schedule. Self-report data revealed that compared to the Actor-Controlled group ($M$ = 3.67, $SD$ = 1.44), the Observer-Controlled ($M$ = 4.78, $SD$ = 1.73) group reported a statistically significantly higher value when reporting the extent to which they controlled the practice schedule to benefit their partner's learning. Similar to the findings from the Actor-Controlled group, the results of the Observer-Controlled group indicate that participants followed the instructions pertaining to role-switching. These findings support the questionnaire as a manipulation check to confirm participants were following the instructions they were provided.

Moreover, the opportunity to switch roles with a partner was the primary factor responsible for the equated movement time scores between the Actor- and Observer-Controlled groups and the Dyad-Alternate group. Although all groups were provided the same number of physical practice and observation trials, the strategies involved in role-switching differed between the groups. For instance, the Dyad-Alternate group was required to switch roles forty times throughout the acquisition period (i.e., after each trial), while the Actor-Controlled and Observer-Controlled groups both chose statistically significant lower switching frequencies. Despite the differing switch frequencies between the dyads that had control, and the dyad that did not, all groups demonstrated similar movement time scores, post practice. These results suggest that despite the differences in switch frequencies, or being afforded control within the dyad, the opportunity to observe their partner during practice was the underlying practice factor equating motor task performance of the dyads. These findings suggest that alternating between physical practice and observation within a dyad was both an effective and efficient method of skill acquisition, regardless of whether or not participants within the dyad are provided control over role-switching.

For the dyads in which participants were provided control (i.e., Actor- and Observer-Controlled groups), it was predicted both groups would demonstrate similar movement time scores on the post-test, but the Observer-Controlled group would perform faster on the retention and transfer tests. Recall, this prediction was first based on the peer-control literature, showing how peers can adequately control the practice schedule of another learner, similar to that of self-controlled learners, for the acquisition of various novel timing tasks (Karlinsky & Hodges, 2014; McRae et al., 2015; Patterson et al., 2019). Secondly, the prediction was based on the observational learning literature, showing how the observation of a learning model can enhance error identification and correction processes, and result in a strong cognitive representation of the skill (Deakin & Proteau, 1998; Shea et al., 2000). This prediction was partially supported, in that both groups showed relatively similar movement time scores on the post-test. Movement time results from the delayed retention and transfer tests, however, failed to support this prediction such that no statistically significant differences were found between the Actor- and Observer-Controlled groups. These findings are similar to McRae et al. (2015) who also showed that learners whose practice schedules were controlled by inexperienced peers demonstrated similar absolute, constant, and variable error, compared to learners with self-control during the acquisition of a key-pressing timing task. Moreover, the present results support Karlinsky and Hodges (2014), who showed practice contexts controlled by an inexperienced peer on a key-stroke timing task also demonstrated similar movement time error compared to learners with self-control on a delayed retention test.

Although the prediction was partially supported, the movement time results support the information-processing perspective, suggesting that the similarities in movement time between the groups were due to the adaptive structure of performance-contingent practice, independent of which partner had control. Previous research has suggested the benefits associated with self-controlled practice are attributed to the notion that learners tailor their practice environment to meet their own preferences (Chiviacowsky & Wulf, 2002; Karlinsky & Hodges, 2014; Keetch &

Lee, 2007; Post et al., 2014). In the present experiment, similarities in movement time between the Actor- and Observer-Controlled groups were perhaps due to the individualized schedules chosen by both the Actors and Observers. For instance, it was previously established that participants in both groups followed their role-switching instructions, such that all participants scheduled practice to benefit the partner physically practicing the task. Since participants in the Actor-Controlled group controlled their own schedule, previous research would suggest that their KR (available after each trial) and task-related intrinsic sensory feedback guided their role-switching decisions, resulting in performance-contingent practice (Karlinsky & Hodges, 2014; Keetch & Lee, 2007). However, participants in the Observer-Controlled group had their practice schedule controlled by their partner, yet their movement time scores on the post-test were similar to the participants in the Actor-Controlled group. Therefore, it is possible both groups adopted individualized practice schedules throughout the acquisition period resulting in comparable movement time scores in the post-test. Self-report data provides support for this explanation as 91.7% of participants in both groups reported they agreed with their partner's decisions in that they switched roles following the appropriate trials. Thus, both the Actor's and Observer's decisions were commensurate with their partner's preferences, highlighting individualized, performance-contingent, practice schedules. These results extend our knowledge on dyad practice, showing that peers can effectively organize a practice schedule for another learner, independent of who has control within the dyad.

### 5.2 Switching Characteristics

It was predicted both the Actor- and Observer-Controlled groups would choose to switch roles primarily following perceived good trials. This prediction was based Karlinsky and Hodges (2014) who showed learners and peers with control chose to switch amongst different key-stroke sequences more commonly after perceived good trials. To this point, the switch trials showed significantly lower absolute error (i.e., good trial) compared to the preceding non-switch trials. The movement time results from the present study do not support the prediction, as there were no statistically significant differences in movement time on the switch and the trials preceding the switch for either dyad group afforded control. The lack of differences suggests there was no preference for switching roles after good or bad trials, for both groups. The self-report data revealed participants in the Observer-Controlled group most frequently self-reported switching roles following perceived good trials (29.2%), whereas participants in the Actor-Controlled group most frequently reported switching roles following perceived both good and bad trials equally (29.2%).

The self-report data from the Actor-Controlled group supports the movement times on switch compared to the trials preceding a switch, whereas the self-report data from the Observer-Controlled group does not. Switching roles after both good and bad trials provides insight into the preferences of the Actors and Observers. For example, an Actor or Observer may decide to switch roles after a perceived good trial because they, or their partner, achieved a certain level of task proficiency (Wu & Magill, 2011). Alternatively, if a learner is performing poorly, taking a break to observe their partner practice could assist in their error identification and correction processes, which in turn could help guide them to the correct motor response.

Although the role-switching strategies from the current experiment are not consistent with Karlinsky and Hodges (2014), it is important to highlight some differences in methodologies between the experiments. First, Karlinsky and Hodges (2014) provided learners control over when to switch between different motor tasks, whereas in the current experiment partners switched roles for one motor task. Therefore, acquiring multiple motor tasks could be considered more complex in comparison to just one motor task, which may have resulted in the exploration of alternative switching strategies. Second, participants in Karlinsky & Hodges (2014) did not alternate with their partner and therefore did not observe their partner. In the present experiment, participants utilized the observation of their partner's motor performance to facilitate their own skill acquisition. Therefore, the error identification and correction processes acquired from observing a partner may have influenced their decisions to switch roles. In summary, the results of the switch versus non-switch trials for both the Actor- and Observer-Controlled dyads suggest independent of the types of trials in which they choose to switch roles, skill acquisition was facilitated.

With regards to switch frequency, it was predicted the Observer-Controlled group would choose to switch roles more frequently than the Actor-Controlled group. This prediction was also based on Karlinsky and Hodges (2014), who showed peers preferred more frequent switches amongst three different key-stroke sequences compared to learners provided self-control. The results from the present study support the prediction. However, despite the findings being consistent with Karlinsky and Hodges (2014), the suggested mechanisms likely differ. For instance, in the present study, while in the Observer role, participants lacked task-related intrinsic sensory feedback regarding their partner's performance and were prohibited from engaging in any form of communication with their partner. Accordingly, the only performance-related information available to aid their decisions, was their partner's KR. Therefore, given the limited task-related information compared to the Actor-Controlled group, it is possible the Observers chose to switch roles more frequently because they required more attempts in determining what was best for their partner. Moreover, it is also possible the Observers wanted to practice the task themselves more often, rather than observe. In this context, the Observers switched roles more frequently than the Actors, because they wanted to improve their own performance instead of observing their partner. Thus, the Observers could end their partner's practice, so they could practice themselves, whereas the Actors could continue practicing without their partner interfering, hence less frequent switches compared to the Observer-Controlled group. While the goal was for both partners within the dyad to achieve success in the retention test, the Observers controlled the schedule to benefit their partner to a certain extent, while perhaps also being cautious of their own performance to ensure they weren't the "weak link" within their dyad. The within-group analysis showed no statistically significant differences between self-reported values for the Observer-Controlled group, when asked the extent to which they controlled their schedule to benefit their partner's learning, in comparison to their own. This provides further support for the participants in the Observer-Controlled group controlling their schedule not just to the benefit of their partner, but with their own performance in mind as well.

While the Observer-Controlled group chose to switch roles significantly more than the Actor-Controlled group, correlational data showed that this higher frequency of role-switching within the Observer-Controlled group was not statistically associated with faster movement times. For the Actor-Controlled group, however, a statistically significant negative correlation was found, such that a higher frequency of role-switching was significantly associated with decreased movement times (i.e., better performance) throughout the acquisition period. This significant correlation suggests that the Actor's utilized their movement time scores to base their role-switching decisions throughout practice. As previously discussed, in addition to the augmented KR, the Actors also had their intrinsic sensory feedback to aid the interpretation of their performance and subsequently help with their role-switching decisions. Therefore, perhaps the Actors were able to better utilize task-relevant information (i.e., feedback) to guide their role-switching decisions, in comparison to the Observers who had to rely solely on their partner's KR. Alternatively, since the Observer's decisions were not significantly associated with their partner's performance, it is possible they utilized a different strategy when deciding whether or not to switch roles with their partners. As mentioned in the previous section, the Observer's decisions were perhaps based on wanting to practice the task themselves, rather than observing their partner. The correlational data provides further support for this explanation, as the Observer's decisions were not based on their partner's movement time scores, but instead something different. While these measures do not allow for a stronger conclusion, the fact that the Observer-Controlled group switch roles significantly more often, without being correlated with their partner's movement time, it is evident the mechanisms involved in the role-switching processes differed between groups.

Despite the apparent differences in role-switching strategies (i.e., frequency of switching, and the association with movement times throughout practice) between the Actor- and Observer-Controlled groups, it is important to note that learning was not differentially impacted. Therefore, these findings provide a novel contribution to the dyad literature, such that while the groups learned the task similarly, the mechanisms within the dyads differed as a function of which partner had control. These unique findings provide a solid foundation for future research to further explore the decision-making processes and the underlying mechanisms to explain how and why they differ.

### 5.3 Performance Errors

For the acquisition and retention period, it was predicted the dyad groups (i.e., Actor-Controlled, Observer-Controlled, Dyad-Alternate) would commit less minor and major errors in comparison to the Control group. This prediction was based on the observational learning literature, as it has been suggested that the observation of a learning model facilitates error identification and correction processes (Lee & White, 1990; Ste-Marie et al., 2012). The results from the acquisition period in the present experiment revealed no statistically significant differences between groups, for both minor and major errors. Further, no statistically significant differences for minor and major errors were found between groups, at pre-test, post-test, retention, and transfer. In this context, the results failed to support our prediction. Since the Control group experienced twice as much physical practice in comparison to the dyad groups (i.e., Actor-Controlled, Observer-Controlled, Dyad-Alternate), the additional practice trials perhaps facilitated error detection and correction processes to a similar extent to what the dyad groups experienced during the observation of their partner. These findings provide further support for dyad practice as an efficient method of training, showing that despite only experiencing half as much physical practice with the task, dyad learners were as accurate in their performance compared to individual learners. Thus, the findings suggest that the observation of a partner is a sufficient alternative to additional physical practice and therefore provide support for alternating dyad practice.

The results from the *Task Evaluation Questionnaire* (TEQ) showed no statistically significant differences between all groups, on all subscales. Recall, the OPTIMAL theory proposes that providing learners with control supports their psychological need for autonomy, which increases their intrinsic motivation, leading to enhanced skill acquisition (Wulf & Lewthwaite, 2016). Thus, the results from the current experiment do not provide support for the OPTIAML theory, as the groups who were afforded control did not self-report greater intrinsic motivation compared to the groups who were not afforded control. In addition, the groups provided control over their role-switching schedule did not demonstrate enhanced learning in comparison to the groups who were not provided control. Although the results do not support the OPTIMAL theory, it is important to note that intrinsic motivation was only measured once throughout the experimental protocol (i.e., at the end of Day 1). Since we are unaware of motivation levels prior to practice, or on Day 2, we are unable to draw stronger conclusions regarding the motivational mechanisms involved in having control over role-switching schedules. Therefore, the results from the TEQ and its relationship with the OPTIMAL theory should be considered with caution.

From an applied perspective, the current experiment has practical implications for dyad practice. There are various situations, such a team practices or group rehabilitation sessions, whereby learners rely on one another to facilitate skill acquisition. The results of the present experiment provide insight to this relationship as they demonstrate that learners can practice more efficiently in dyads, without undermining learning. Further, the current experiment demonstrates how both Actors and Observers within a dyad can be provided control over their role-switching schedule and different strategies can be adopted, to perpetuate learning.

## 6.0 Limitations

There are certain limitations in the present experiment that should be identified for the purpose of future research. For instance, throughout the experimental protocol, the researcher was responsible for identifying and recording when an error (i.e., either minor or major) was committed. Although the criteria for a major error was obvious (i.e., when a cup fell off the table), the criteria for a minor error was not. For example, minor errors included any form of mistake made by the participant throughout a trial, while the cups remained on the table (i.e., a participant fumbling a cup). However, the task for the current experiment allowed participants to explore a multitude of different techniques to achieve success. Therefore, since the criteria for a minor error was relatively vague, the use of a new task technique could have been mistaken for an error, given participants were moving quickly. Thus, future studies should consider more accurate and appropriate measures to ensure the adequate identification of minor errors. We recommend a detailed description of what constitutes a minor error, and perhaps enforce a specific task technique that participants must adopt (and if failed to, they must redo the trial), to allow the researchers to better detect and distinguish errors.

Another limitation of this study is that intrinsic motivation was only measured once throughout the experimental protocol. Motivation is an important measure to include, especially since it is theorized as an underlying mechanism responsible for the benefits associated with self-controlled practice schedules (Chiviacowsky & Wulf, 2002; Wulf & Lewthwaite, 2016). In the current experiment, however, motivation was only measure once, at the end of Day 1. This indicates a limitation, as we are unaware of motivation levels prior to the acquisition phase, and both before and after the retention and transfer tests. Including measures of motivation before practice and before and after tests on day 2, would further our theoretical understanding of such practice conditions, and provide better insight to the mechanisms involved.

## 7.0 Future Directions

A future experiment should examine the impact of undirected dialogue between partners who have control over their role-switching schedule. In the present study, participants were required to make role-switching decisions alone, without collaborating with their partner. Therefore, it would be interesting to examine controlled role-switching when both partners can communicate and make such decisions together. From an applied standpoint, allowing partners to communicate throughout practice would better highlight practical situations, as dialogue is typically incorporated in both sport and rehabilitation settings. Examining the effects of dyad learners collectively controlling their practice schedule would more accurately represent applied environments.

Moreover, the present experiment did not include true “self-controlled” and “peer-controlled” practice conditions. For example, although the participants in the Actor-Controlled group were controlling their own practice schedule, they were also controlling their partner’s, as their individual decisions influenced their dyad’s schedule. Similarly, in the Observer-Controlled group, participants were controlling their partner’s schedule, but indirectly also controlling their own, as their decisions impacted both partner’s schedules. Therefore, future studies may incorporate true self- and peer-controlled practice conditions to further both our theoretical and practical understanding of such schedules within a dyad practice context. In addition, the inclusion of true self- and peer-controlled practice conditions would perhaps better reveal the benefits of control for motor learning.

The current experiment incorporated both quantitative analyses and self-report measures to examine different switching strategies used throughout practice. A future direction could be to implement a questionnaire incorporating open-ended questions, probing deeper explanations for the decisions made throughout practice. The addition of open-ended questions would allow researchers to better determine when and why learners choose to switch roles with a partner.

Finally, the present experiment paired participants based on gender (i.e., males with males, and females with females). To date, no experiment has examined the effects of dyad practice as a function of gender amongst partners. Thus, more research in this area is needed to investigate the impact of gender within a dyad practice context, and whether or not learning is differently modulated by the gender of one’s partner. This would provide a greater insight to the mechanisms involved in paired practice and would further our practical understanding of dyad practice environments.

## 8.0 Conclusion

The first purpose of this experiment was to determine if providing dyad learners with control over their role-switching schedule would differentially impact learning compared to a traditional alternating dyad (i.e., a fixed schedule of switching roles after each trial) and individual practice. Further, we sought to examine the potential differences between when the Actor has control versus the Observer and determine the role-switching strategies adopted by the participants when provided control. The predictions of the Actor- and Observer-Controlled groups performing faster (i.e., better) than the Dyad-Alternate and Control groups, were not supported, suggesting that allowing learners to control when they switch roles with their partner is as effective as both a fixed schedule of switching roles after each trial, as well as individual practice. These findings address a gap in knowledge by highlighting the flexible and dynamic nature of dyad practice. Specifically, our results show how dyad practice facilitated skill acquisition, independent of whether or not participants had control over their role-switching schedule, and further demonstrated how controlled role-switching within a dyad is more efficient than individual practice. In addition, the prediction that the Observer-Controlled group would demonstrate faster movement time on the retention test compared to the Actor-Controlled group, was not supported. This finding provides a novel contribution to the literature, such that both Actors and Observers can adequately control the role-switching schedule to promote motor learning. Furthermore, our experiment addresses a current gap in the literature by examining the role-switching strategies adopted by both Actors and Observers within a dyad. The Observers most commonly reported switching roles following perceived good trials, whereas the Actors most commonly reported switching roles following perceived good and bad trials equally. This novel finding highlights the role-switching preferences of the Actors and Observers, with perhaps different reasons for switching roles after different types of trials. Finally, the Observers chose to switch roles more frequently than the Actors, which also demonstrates a novel contribution to the literature. While there is evidence of peer-schedulers choosing to switch between different tasks more frequently than self-scheduled learners (Karlinsky & Hodges, 2014), the current experiment is the first to show this trend within a dyad environment where both partners physically practice the task. Overall, the frequency of role-switching results demonstrate how various switching strategies can be adopted throughout dyad practice, without undermining learning. In conclusion, the results of the present experiment show that both Actor- and Observer-Controlled dyad practice are effective and efficient methods of practice, during the acquisition and retention of a motor task.

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**LIST OF TABLES**

**Table 1. Mean Movement Time Scores – Pre, Post, Retention, Transfer**
*Mean scores (standard deviations) for movement time throughout Day 1 and Day 2. Scores are provided for the Actor-Controlled (AC), Observer-Controlled (OC), Dyad-Alternate (DA), and Control (C) groups. Scores are presented in milliseconds.*

| Group | Pre-Test | Post-Test | Retention | Transfer |
|---|---|---|---|---|
| AC | 14246.9 (2107.8) | 9700.1 (890.1) | 9223.1 (896.2) | 15113.5 (2524.3) |
| OC | 14637.1 (2235.8) | 9686.1 (1188.3) | 9357.0 (1180.9) | 15812.2 (2914.1) |
| DA | 13512.8 (2700.7) | 9415.3 (1368.4) | 8802.3 (1194.6) | 15377.7 (2994.4) |
| C | 13757.1 (1828.4) | 9176.6 (847.0) | 9001.3 (809.5) | 16431.0 (2514.0) |

**Table 2. Mean Movement Time Scores – Acquisition (Physical Practice Equated Amongst Dyads)**
*Mean scores (standard deviations) for movement time throughout the acquisition period. The acquisition period was divided into 4 blocks of 10 trials, and analyzed per dyad. For instance, Block 1 included the dyad's first 10 trials, collectively, regardless of which partner completed such trials. Scores are provided for the Actor-Controlled (AC), Observer-Controlled (OC), Dyad-Alternate (DA), and Control (C) groups. Scores are presented in milliseconds.*

| Group | Block 1 | Block 2 | Block 3 | Block 4 |
|---|---|---|---|---|
| AC | 11577.8 (1458.1) | 10715.1 (1039.2) | 10025.0 (1079.8) | 9645.3 (780.0) |
| OC | 11577.6 (1267.7) | 10935.3 (835.0) | 10125.1 (995.7) | 9674.8 (1195.6) |
| DA | 10859.3 (1352.9) | 9701.5 (977.4) | 9557.1 (732.7) | 9414.7 (838.5) |
| C | 10632.9 (1170.0) | 10067.9 (1031.3) | 9441.2 (1069.1) | 9030.7 (1008.1) |

**Table 3. Mean Movement Time Scores – Acquisition (Physical Practice Equated Within Dyads)**

*Mean scores (standard deviations) for movement time throughout the acquisition period. The acquisition period was divided into 4 blocks of 5 trials for the Actor-Controlled (AC), Observer-Controlled (OC), Dyad-Alternate (DA) groups, and 4 blocks of 10 trials for the Control (C) group. These data were analyzed per individual participant. For instance, Block 1 was each participant's first 5 (or 10) physical practice trials, regardless of when they occurred during the practice period. Scores are presented in milliseconds.*

| Group | Block 1 | Block 2 | Block 3 | Block 4 |
|---|---|---|---|---|
| AC | 11448.1 (1723.5) | 10706.0 (1202.0) | 10197.2 (1225.3) | 9612.0 (1103.0) |
| OC | 11593.4 (1586.6) | 10865.7 (1015.6) | 10087.1 (1347.1) | 9766.5 (1286.9) |
| DA | 10880.1 (1846.5) | 9701.5 (1465.0) | 9557.1 (1369.5) | 9414.7 (1168.4) |
| C | 10632.9 (1170.0) | 10067.9 (1031.3) | 9441.2 (1069.1) | 9030.7 (1008.1) |

**Table 4. Mean Switching Frequency Scores**

*Mean scores (standard deviations) for the number of switches made throughout the acquisition period. The acquisition period was divided into 4 blocks of 10 trials. Scores are provided for the Actor-Controlled (AC) and Observer-Controlled (OC) groups.*

| Group | Block 1 | Block 2 | Block 3 | Block 4 |
|---|---|---|---|---|
| AC | 1.58 (.67) | 1.83 (.39) | 1.50 (.52) | 1.67 (.49) |
| OC | 2.17 (.72) | 2.00 (.60) | 1.58 (.52) | 2.00 (.74) |

**Table 5. Mean Switch and Non-Switch Scores**

*Mean movement time scores (standard deviations) for the switch and non-switch (switch-1) trials throughout the acquisition period. Scores are provided for the Actor-Controlled (AC) and Observer-Controlled (OC) groups. Scores are presented in milliseconds.*

| Group | Switch Trials | Non-Switch Trial |
|---|---|---|
| AC | 10470.93 (1310.57) | 10510.64 (1167.86) |
| OC | 10499.78 (1358.19) | 10588.92 (1147.66) |

**Table 6. Switching Characteristics Questionnaire – Actor- and Observer-Controlled Groups**

*The number of responses from the Actor-Controlled (n=24) and Observer-Controlled Groups (n=24) are displayed.*

| Item | Actor-Controlled | Observer-Controlled |
|---|---|---|
| **1. When your partner was in control of the practice schedule, do you think they switched roles after the right trials?** | | |
| a) Yes | 22 | 22 |
| b) No | 2 | 2 |
| **2. If NO, when would you have liked for your partner to switch roles? If YES, skip to question 3#.** | | |
| a) After Perceived Good Trials | 0 | 0 |
| b) After Perceived Bad Trials | 2 | 0 |
| c) After Perceived Good & Bad Trials Equally | 0 | 1 |
| d) Randomly | 0 | 1 |
| e) Other | 0 | 0 |
| **3. When your partner was in control of the practice schedule, how well did their decisions to switch roles facilitate your learning?** ***Note: 1= "did not facilitate my learning at all", 4= "somewhat facilitated my learning", 7= "completely facilitated my learning"*** | Mean = 4.2<br>SD = 1.17 | Mean = 4.7<br>SD = 1.37 |
| **4. When you were in control of the practice schedule, when/why did you decide to switch roles?** | | |
| a) After Perceived Good Trials | 3 | 7 |
| b) After Perceived Bad Trials | 5 | 5 |
| c) After Perceived Good & Bad Trials Equally | 7 | 6 |
| d) Randomly | 6 | 4 |
| e) Other | 3 | 2 |

| | | |
|---|---|---|
| **5. When you were in control of the practice schedule, when/why did you NOT decide to switch roles?** | | |
| a) After Perceived Good Trials | 10 | 11 |
| b) After Perceived Bad Trials | 4 | 6 |
| c) After Perceived Good & Bad Trials Equally | 0 | 3 |
| d) Randomly | 6 | 3 |
| e) Other | 4 | 1 |

**Table 7. Switching Characteristics Questionnaire – Dyad-Alternate Group**
*The number of responses from the Dyad-Alternate Group (n=22) are displayed in the brackets.*

1. **How well did switching roles (i.e., Actor and Observer) after each trial facilitate your learning? *Note: 1= "did not facilitate my learning at all", 4= "somewhat facilitated my learning", 7= "completely facilitated my learning"***

   Mean = 4.3, SD = 1.39

2. **Would you have liked to have control over when to switch between roles?**

   a) Yes (11)
   b) No (11)

3. **If Yes, when would you have switched roles? If NO, questionnaire is complete.**

a) After Perceived Good Trials (6)
b) After Perceived Bad Trials (3)
c) After Perceived Good & Bad Trials Equally (2)
d) Randomly (0)
e) Other (0)

**Table 8. Switching Characteristics Questionnaire – Control Group**
*The number of responses from the Control Group (n=15) are displayed in the brackets.*

1. **How well would switching roles (i.e., Actor and Observer) after each trial have facilitate your learning? *Note: 1= "did not facilitate my learning at all", 4= "somewhat facilitated my learning", 7= "completely facilitated my learning"***

   Mean = 4.9, SD = 1.21

2. **Would you have liked to have control over when to switch between roles?**

   a) Yes (7)
   b) No (8)

3. **If Yes, when would you have switched roles? If NO, questionnaire is complete.**

a) After Perceived Good Trials (1)
b) After Perceived Bad Trials (2)
c) After Perceived Good & Bad Trials Equally (3)
d) Randomly (1)
e) Other (0)

**Table 9. Mean Errors Scores – Acquisition**

*Mean scores (standard deviations) for the number of minor and major errors committed throughout the acquisition period. The acquisition period was organized into 4 blocks of 10 trials. Scores are provided for the Actor-Controlled (AC), Observer-Controlled (OC), Dyad-Alternate (DA), and Control (C) groups.*

| Group | Block 1 | Block 2 | Block 3 | Block 4 |
|---|---|---|---|---|
| | **Minor Errors** | | | |
| AC | 2.25 (1.91) | 2.42 (2.11) | 2.17 (1.19) | 2.42 (2.02) |
| OC | 2.67 (1.97) | 2.50 (1.00) | 2.41 (1.44) | 2.83 (1.90) |
| DA | 3.00 (1.84) | 2.36 (1.86) | 3.64 (1.86) | 2.64 (2.73) |
| C | 2.73 (2.40) | 2.93 (1.75) | 2.13 (1.36) | 2.73 (1.33) |
| | **Major Errors** | | | |
| AC | 0.25 (0.45) | 0.33 (0.49) | 0.58 (1.16) | 0.42 (0.67) |
| OC | 0.58 (0.79) | 0.75 (0.62) | 0.33 (0.65) | 0.58 (1.16) |
| DA | 1.27 (1.27) | 0.27 (0.65) | 0.45 (0.82) | 0.36 (0.50) |
| C | 0.27 (0.59) | 0.47 (0.74) | 0.40 (0.63) | 0.33 (0.82) |

**Table 10. Mean Error Scores**

*Mean scores (standard deviations) for the number of minor and major errors committed on Day 1 and Day 2. Scores are provided for the Actor-Controlled (AC), Observer-Controlled (OC), Dyad-Alternate (DA), and Control (C) groups.*

| Group | Pre-Test | Post-Test | Retention | Transfer |
|---|---|---|---|---|
| | **Minor Errors** | | | |
| AC | .96 (.75) | 1.08 (1.10) | 1.00 (.89) | 1.13 (.99) |
| OC | 1.00 (1.22) | 1.33 (1.13) | 1.08 (1.06) | 1.46 (1.32) |
| DA | 1.09 (.92) | 1.55 (1.14) | 1.50 (1.01) | 1.82 (1.30) |
| C | 1.40 (1.68) | 1.22 (1.05) | 1.07 (1.10) | 1.40 (1.06) |
| | **Major Errors** | | | |
| AC | 0.50 (.78) | 0.29 (.46) | 0.21 (.51) | 0.54 (.83) |
| OC | 0.54 (.66) | 0.17 (.48) | 0.17 (.38) | 0.50 (.66) |
| DA | 0.36 (.66) | 0.50 (.91) | 0.05 (.21) | 0.73 (.83) |
| C | 0.33 (.49) | 0.33 (.62) | 0.33 (.49) | 0.67 (.49) |

**Table 11. Task Evaluation Questionnaire**

*Mean (standard deviations) values for the Task Evaluation Questionnaire, divided into subscales: Interest/Enjoyment, Pressure/Tension, Perceived Competence, Perceived Choice, and both partner-related versions of Perceived Competence and Perceived Choice for the Actor-Controlled (AC), Observer-Controlled (OC), Dyad-Alternate (DA), and Control (C) groups. The values are based off a scale from 1-7 (1 = "not at all true", 4 = "somewhat true", 7 = "very true").*

| Group | Interest/ Enjoyment | Pressure/ Tension | Perceived Competence | Perceived Choice | Partner Competence | Partner Choice |
|---|---|---|---|---|---|---|
| AC | 4.83 (1.23) | 4.14 (.88) | 3.79 (.96) | 5.33 (1.14) | 4.48 (.76) | 3.21 (.72) |
| OC | 5.11 (1.08) | 4.50 (1.13) | 3.73 (1.15) | 5.78 (.87) | 4.46 (.86) | 3.11 (.72) |
| DA | 5.00 (1.03) | 4.45 (1.42) | 3.67 (1.14) | 5.05 (1.46) | 4.83 (.66) | 3.49 (.95) |
| C | 4.39 (.94) | 3.97 (1.47) | 3.51 (.91) | 5.57 (.87) | - | - |

**Table 12. Paired Practice Experience Questionnaire**

*Visual representation of the paired practice experience questionnaire, indicating which questions were asked to which groups. The "x" indicates that the question was asked to that specific group. Table represents questions asked to the Actor-Controlled (AC), Observer-Controlled (OC), Dyad-Alternate (DA), and Control (C) groups.*

| Question | AC | OC | DA | C |
|---|---|---|---|---|
| "Watching my partner helped my own performance" | x | x | x | |
| "Watching my partner interfered with my own performance" | x | x | x | |
| "Watching my partner would have helped my own performance" | | | | x |
| "Watching my partner would have interfered with my own performance" | | | | x |
| "I wanted to perform faster than my partner on Day 2" | x | x | x | x |
| "I controlled the practice schedule (i.e., the order in which my partner and I practiced the cup-stacking task) to benefit my partner's learning" | x | x | | |
| "I controlled the practice schedule (i.e., the order in which my partner and I practiced the cup-stacking task) to benefit my own learning" | x | x | | |
| "I wanted to perform faster than the top 5 pairs listed in the laboratory" | x | x | x | x |
| "I would have preferred to practice alone" | x | x | x | x |

**Table 13. Frequency of Role-Switching and Movement Time Correlations**

*The correlation between the frequency of role-switching throughout the acquisition period and movement time scores for the Actor-Controlled (AC) and Observer-Controlled (OC) Groups during the acquisition period, post-test, retention test, and transfer test.*

| Group | Acquisition | Post-Test | Retention Test | Transfer Test |
|---|---|---|---|---|
| AC | -.435* | -.120 | -.287 | -.282 |
| OC | .118 | -.100 | .108 | -.107 |

*Note:* *$p < .05$, two-tailed

**LIST OF FIGURES**

**Figure 1. Mean Movement Time Scores (Acquisition Trials Equated Amongst Dyads)**
*The mean movement time scores on Day 1 and Day 2. Day 1 scores are shown for the Pre-test (Pre), the acquisition trials equated amongst dyad (i.e., analyzed per dyad): block 1 (B1), block 2 (B2), block 3 (B3), block 4 (B4), and the Post-test (Post). Day 2 scores are shown for the retention test (RT) and transfer test (TT). Mean scores are provided for the Actor-Controlled (AC), Observer-Controlled (OC), Dyad-Alternate (DA, and Control (C) groups. Error bars represent standard deviation.*

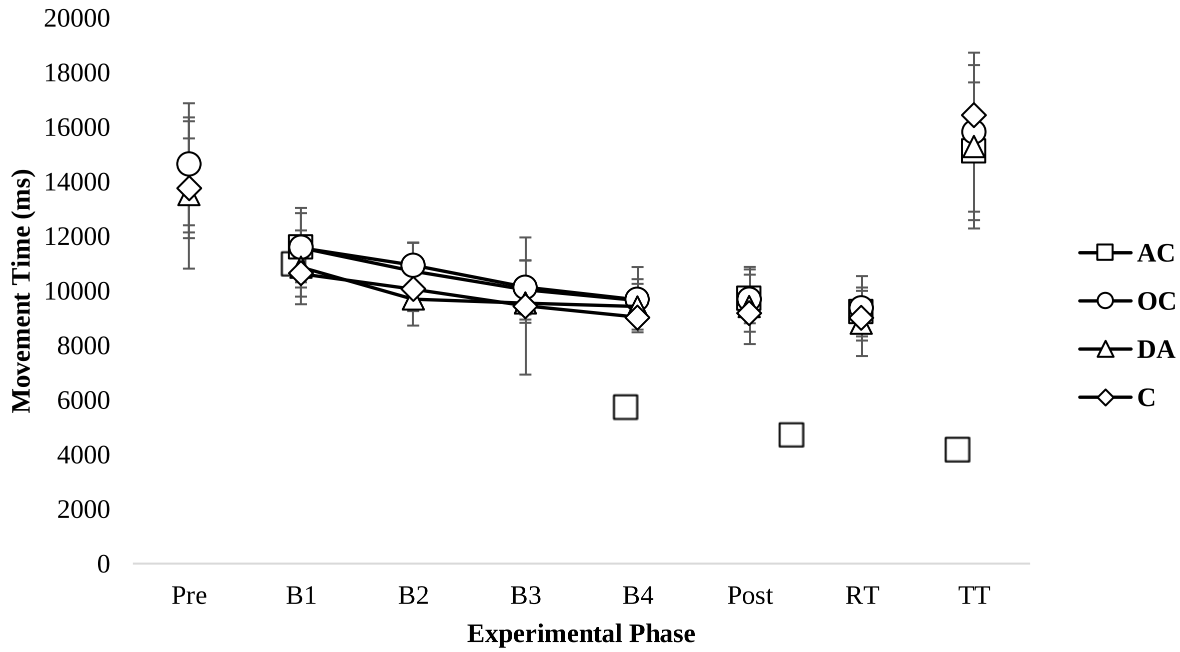


**Figure 2. Mean Movement Time Scores – (Acquisition Trials Equated Within Dyads)**
*The mean movement time scores on Day 1 and Day 2. Day 1 scores are shown for the Pre-test (Pre), the acquisition trials equated within dyads (i.e., analyzed per individual participant): block 1 (B1), block 2 (B2), block 3 (B3), block 4 (B4), and the Post-test (Post). Day 2 scores are shown for the retention test (RT) and transfer test (TT). Mean scores are provided for the Actor-Controlled (AC), Observer-Controlled (OC), Dyad-Alternate (DA, and Control (C) groups. Error bars represent standard deviation.*

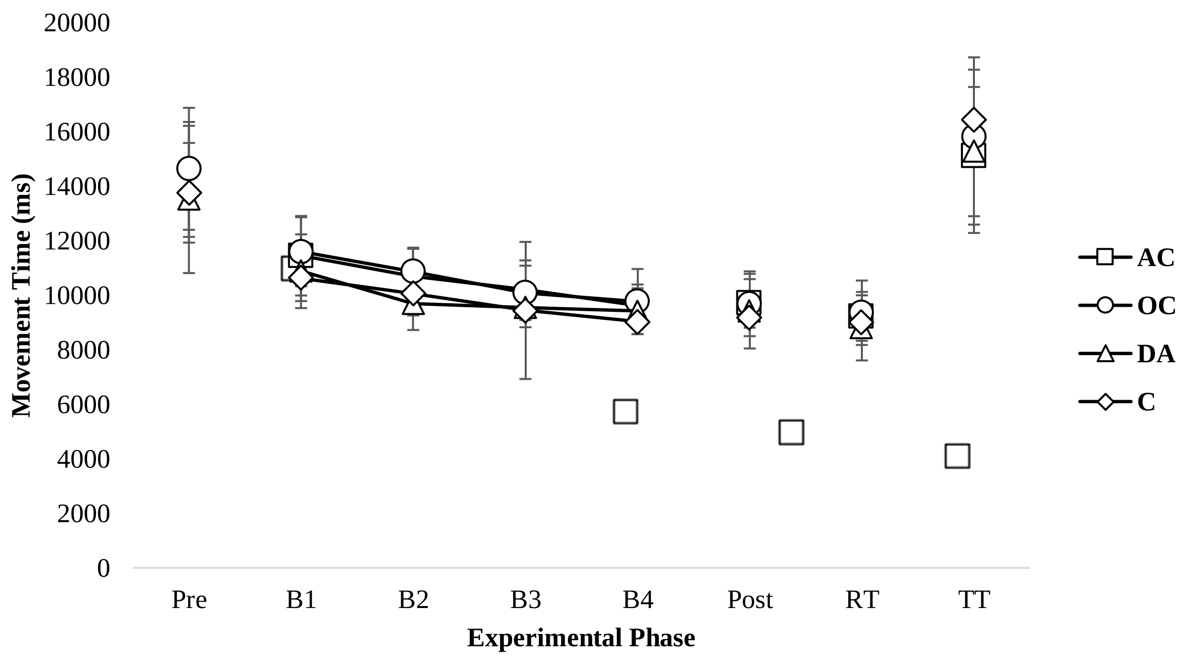


**Figure 3. Mean Number of Minor Errors**

*Mean number of minor errors committed on Day 1 and Day 2. Day 1 errors are shown for the Pre-test (Pre), the acquisition phase: block 1 (B1), block 2 (B2), block 3 (B3), block 4 (B4), and the Post-test (Post). Day 2 errors are shown for the retention test (RT) and transfer test (TT). The number of minor errors committed are provided for the Actor-Controlled (AC), Observer-Controlled (OC), Dyad-Alternate (DA), and Control (C) groups. Error bars represent standard deviation.*

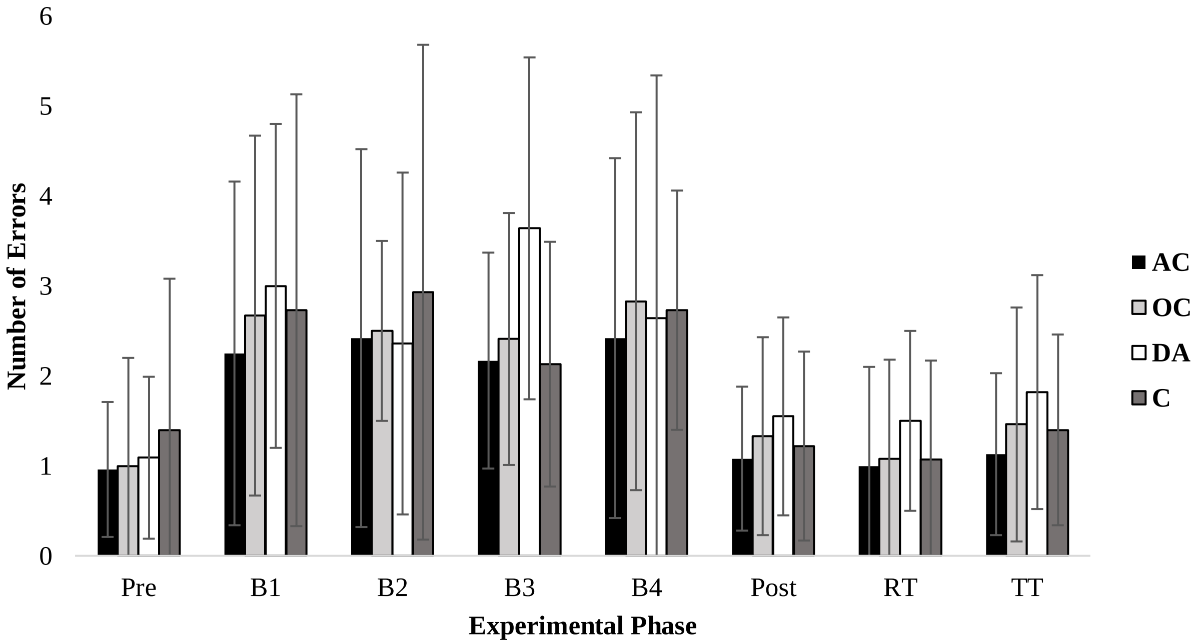


**Figure 4. Mean Number of Major Errors**

*Mean number of Major errors committed on Day 1 and Day 2. Day 1 errors are shown for the Pre-test (Pre), the acquisition phase: block 1 (B1), block 2 (B2), block 3 (B3), block 4 (B4), and the Post-test (Post). Day 2 errors are shown for the retention test (RT) and transfer test (TT). The number of major errors committed are provided for the Actor-Controlled (AC), Observer-Controlled (OC), Dyad-Alternate (DA), and Control (C) groups. Error bars represent standard deviation.*

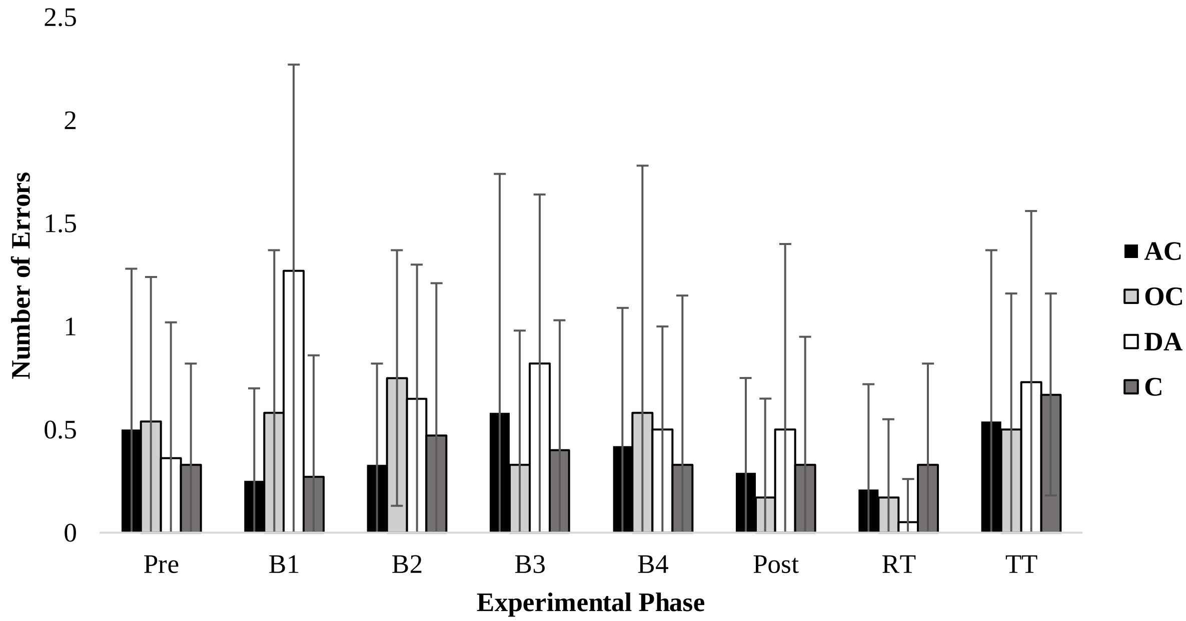


**Figure 5. Frequency of Role-Switching and Average Movement Time Correlation for Acquisition – Actor-Controlled Group**

*Correlation between the frequency of role-switching throughout the acquisition period and the average movement time during the acquisition period, for the Actor-Controlled group.*

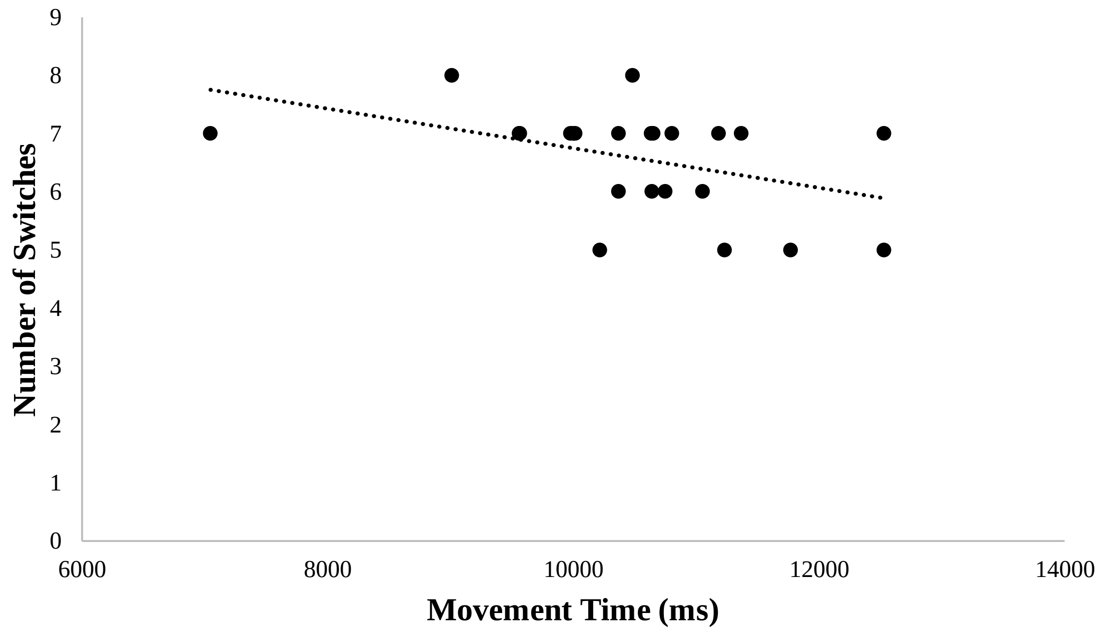


**Figure 6. Frequency of Role-Switching and Average Movement Time Correlation for Acquisition – Observer-Controlled Group**

*Correlation between the frequency of role-switching throughout the acquisition period and the average movement time during the acquisition period, for the Observer-Controlled group.*

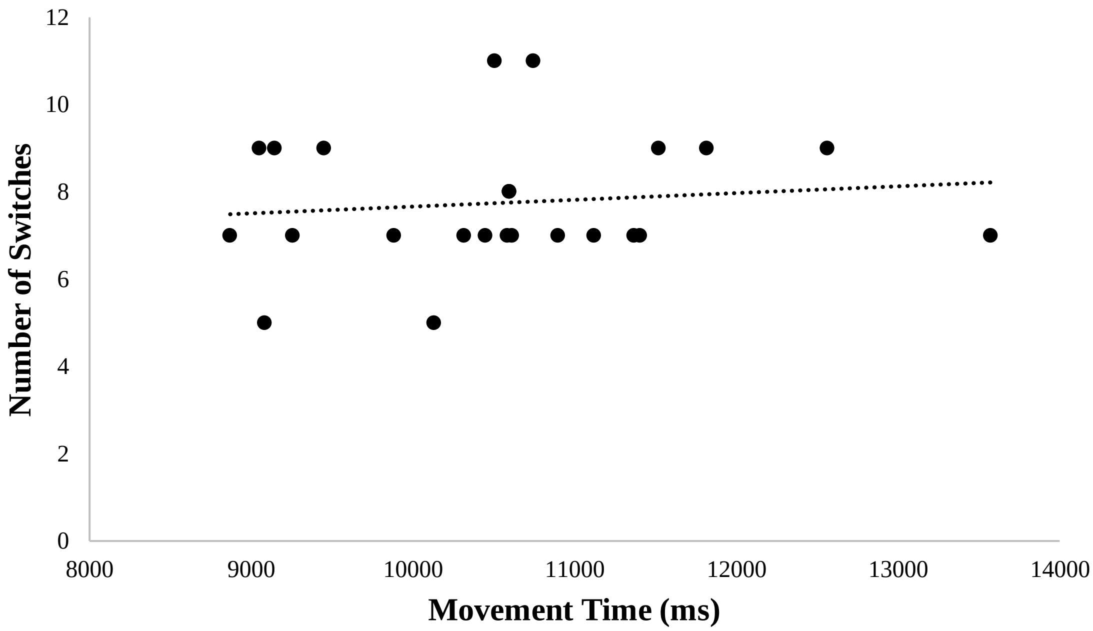


**Figure 7. Frequency of Role-Switching and Average Movement Time Correlation for Post-Test – Actor-Controlled Group**

*Correlation between the frequency of role-switching throughout the acquisition period and the average movement time during the post-test, for the Actor-Controlled group.*

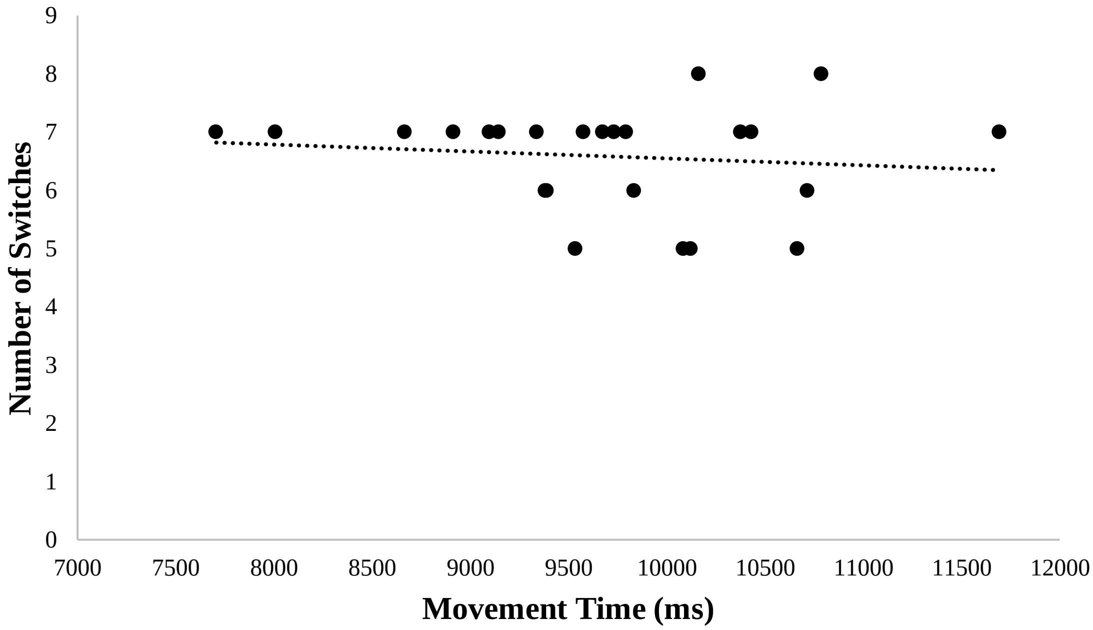


**Figure 8. Frequency of Role-Switching and Average Movement Time Correlation for Post-Test – Observer-Controlled Group**

*Correlation between the frequency of role-switching throughout the acquisition period and the average movement time during the post-test, for the Observer-Controlled group.*

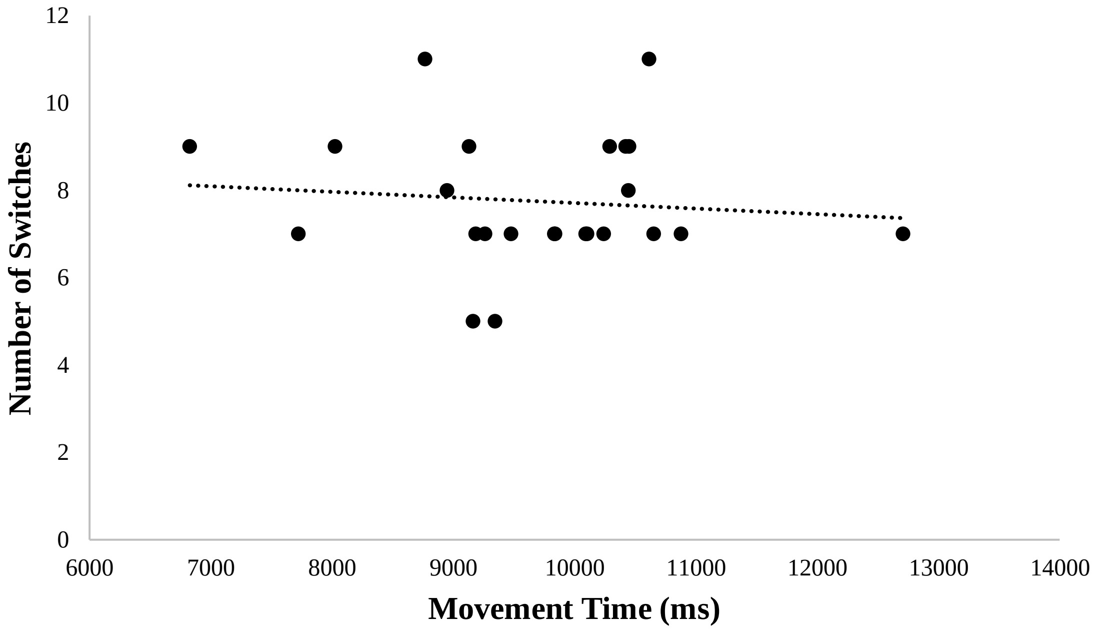


**Figure 9. Frequency of Role-Switching and Average Movement Time Correlation for Retention Test – Actor-Controlled Group**

*Correlation between the frequency of role-switching throughout the acquisition period and the average movement time during the retention test, for the Actor-Controlled group.*

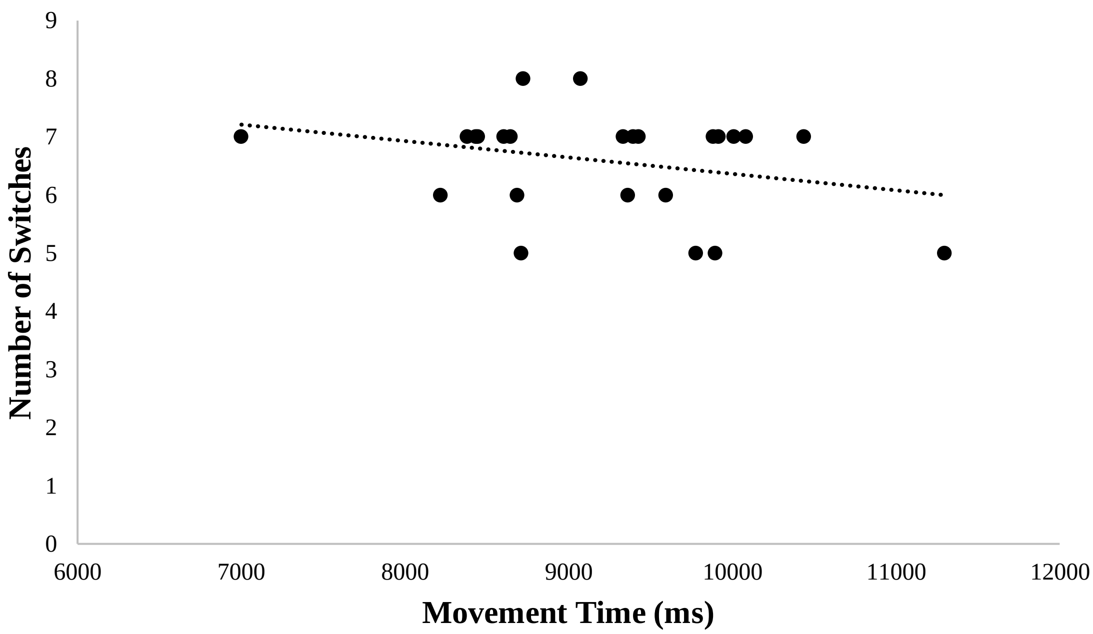


**Figure 10. Frequency of Role-Switching and Average Movement Time Correlation for Retention Test – Observer-Controlled Group**

*Correlation between the frequency of role-switching throughout the acquisition period and the average movement time during the retention test, for the Observer-Controlled group.*

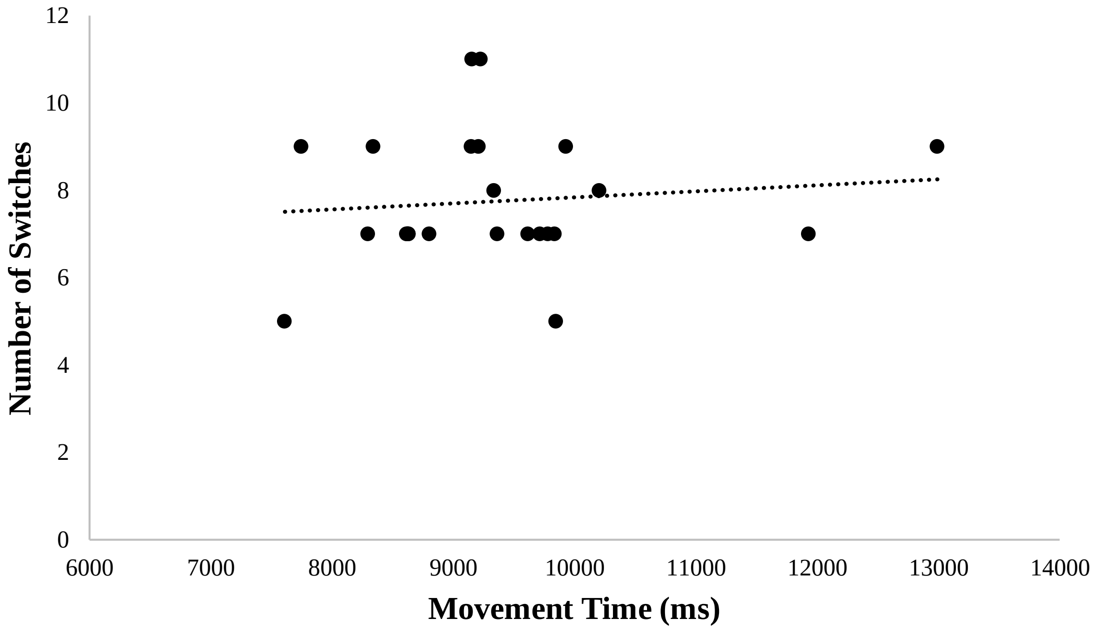


**Figure 11. Frequency of Role-Switching and Average Movement Time Correlation for Transfer Test – Actor-Controlled Group**

*Correlation between the frequency of role-switching throughout the acquisition period and the average movement time during the Transfer test, for the Actor-Controlled group.*

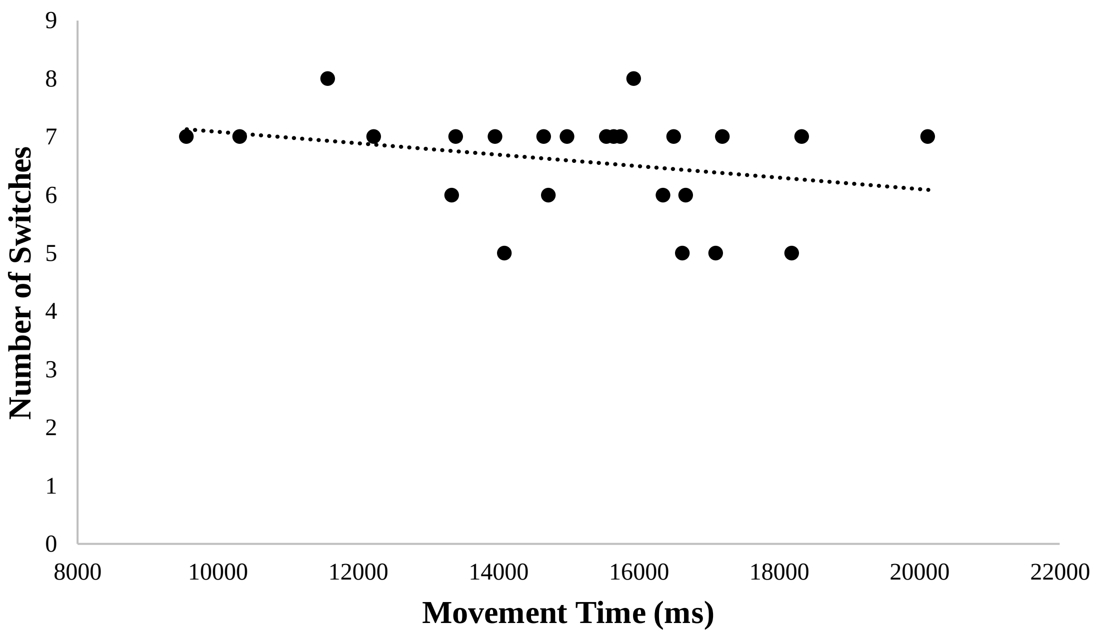
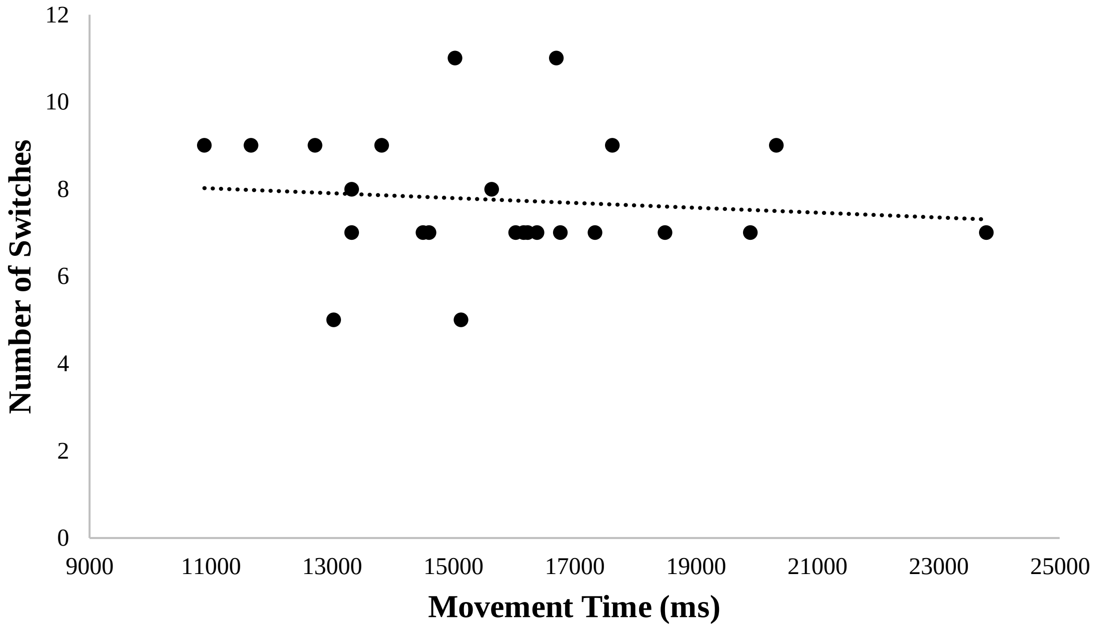


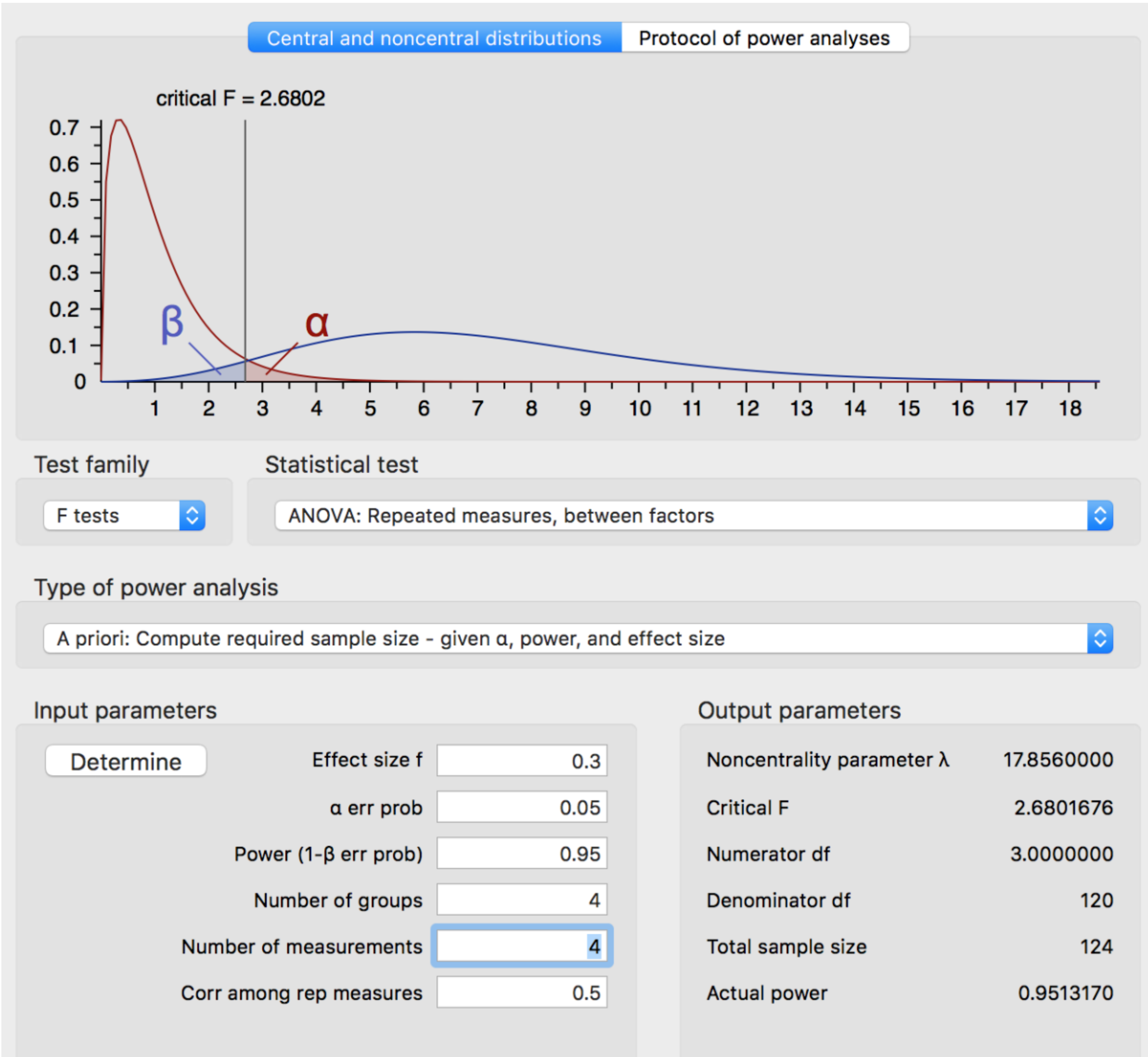
**Figure 12. Frequency of Role-Switching and Average Movement Time Correlation for Transfer Test – Observer-Controlled Group**

*Correlation between the frequency of role-switching throughout the acquisition period and the average movement time during the Transfer test, for the Observer-Controlled group.*



# APPENDICES

## **Appendix A:** G*Power



**Appendix B:** Demographic Questionnaire

---

**1.** Gender: ____________________

**2.** Age: _____ Years

**3.** Dominant Hand: Right☐ Left ☐

**4.** Do you have normal or corrected-to-normal vision? Yes☐ No ☐

**5.** Do you have previous task (i.e., speed cup-stacking) experience? Yes ☐ No☐

*If yes, please describe the level (i.e., competitive or recreational), hours per week, length of participation (i.e., number of years), and coached or self-practiced, in the space provided.*

**6.** On a scale from 1 (I do not know my partner at all) to 7 (I know my partner extremely well), how well do you know your partner?

**1** **2** **3** **4** **5** **6** **7**

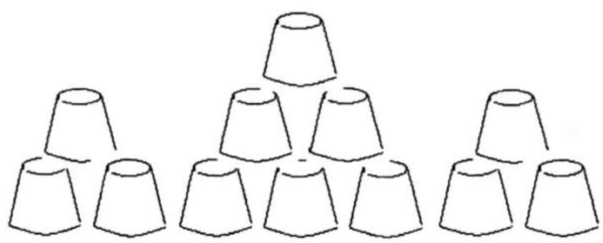
---

**Appendix C:** Cup-Stacking Set-Up

Cup-stacking apparatus set-up for the pre-test, acquisition phase, post-test, and retention test.

Starting Position

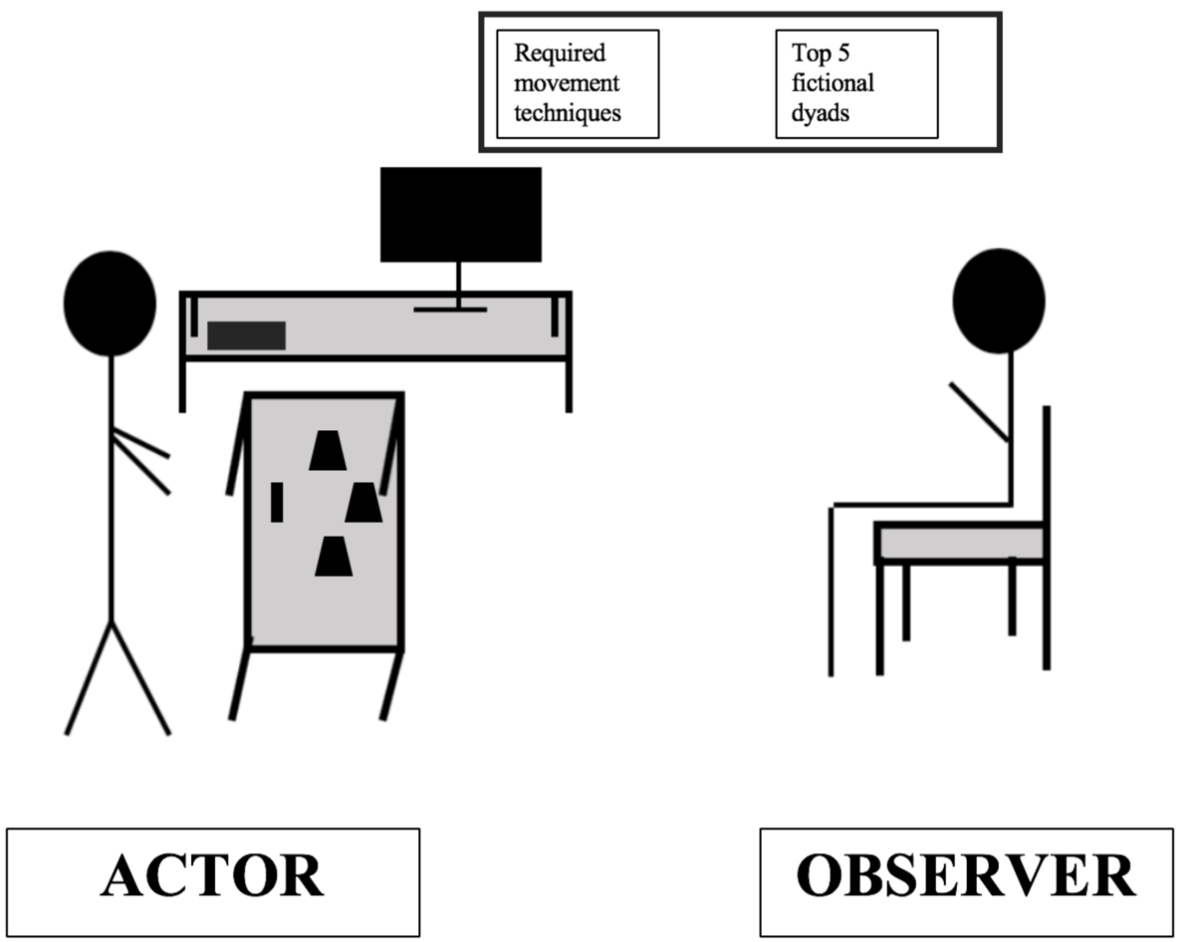
Middle Position



Ending Position

**Appendix D:** Laboratory Set-up

**Laboratory Set-up.** Visual representation of the acquisition period for all groups. The actor will stand behind desk 1, while the observer will sit in the chair, facing each other. The key-pressing device is located in front of the cup-stacking apparatus on Desk 1, and the Dell computer monitor is located on Desk 2 in which the E-Prime customized program will run. The desktop keyboard is also located on Desk 2. On the wall above the computer monitor will be the list of the required movement techniques, as well as the list of the top 5 fictional dyads.



**Appendix E:** Required Movement Techniques

List of required movement techniques.

| | |
|---|---|
| **1** | Hold the cups lightly with fingertips |
| **2** | Alternate between hands, when up-stacking |
| **3** | Slide top cup down side of the bottom cups, when down-stacking |

**Appendix F:** Top 5 Dyads

**Fabricated list of top 5 dyads.** Lower scores represent better performance. The chosen values are based on an expert's performance. Specifically, 10% and 20% greater than and less than an expert's movement time.

| **TEAM #** | **AVERAGE SCORE (ms)** |
|---|---|
| 107 | 5507 |
| 101 | 6220 |
| 109 | 4494 |
| 116 | 4112 |
| 100 | 5008 |

**Appendix G:** Sudoku Puzzle

**Sudoku Puzzle**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 6 | | 9 | | | | | 3 | 1 |
| | 5 | | | | 1 | | | |
| 1 | | | | | 5 | 2 | | |
| | | | 6 | 8 | | | | 4 |
| | 9 | | | | | | 5 | |
| 7 | | | | 4 | 2 | | | |
| | | 8 | 1 | | | | | 2 |
| | | | 3 | | | | 7 | |
| 2 | 3 | | | | | 4 | | 5 |

**Appendix H:** Questionnaires

**Task Evaluation Questionnaire**

---

**1.** While I was working on the cup-stacking task, I was thinking about how much I enjoyed it.
1 2 3 4 5 6 7

**2.** I did not feel at all nervous about doing the cup-stacking task.
1 2 3 4 5 6 7

**3.** I felt that it was my choice to do the cup-stacking task.
1 2 3 4 5 6 7

**4.** I think I am pretty good at this cup-stacking task.
1 2 3 4 5 6 7

**5.** I found the cup-stacking task very interesting.
1 2 3 4 5 6 7

**6.** I felt tense while doing the cup-stacking task.
1 2 3 4 5 6 7

**7.** I think I did pretty well at this cup-stacking activity, compared to other students.
1 2 3 4 5 6 7

**8.** Doing the cup-stacking task was fun.
1 2 3 4 5 6 7

**9.** I felt relaxed while doing the cup-stacking task.
1 2 3 4 5 6 7

**10.** I enjoyed doing the cup-stacking task very much.
1 2 3 4 5 6 7

**11.** I didn't really have a choice about doing the cup-stacking task.
1 2 3 4 5 6 7

**12.** I am satisfied with my performance at this cup-stacking task.
1 2 3 4 5 6 7

**13.** I was anxious about doing the cup-stacking task.
1 2 3 4 5 6 7

**14.** I thought the cup-stacking task was very boring.
1 2 3 4 5 6 7

**15.** I felt like I was doing what I wanted to do while I was working on the cup-stacking task.
1 2 3 4 5 6 7

**16.** I felt pretty skilled at this cup-stacking task.
1 2 3 4 5 6 7

**17.** I thought the cup-stacking task was very interesting
1 2 3 4 5 6 7

**18.** I felt pressured while doing the cup-stacking task.
1 2 3 4 5 6 7

**19.** I felt like I had to do the cup-stacking task.
1 2 3 4 5 6 7

**20.** I would describe the cup-stacking task as very enjoyable.
1 2 3 4 5 6 7

**21.** I did the cup-stacking task because I had no choice.
1 2 3 4 5 6 7

**22.** After working at this cup-stacking task for a while, I felt pretty competent.
1 2 3 4 5 6 7

---

*Note*: 1= “not at all true”, 4= “somewhat true”, 7= “very true

**Paired Practice Experience Questionnaire – Observer-Controlled group**

---

**1.** Watching my partner helped my own performance.

1 2 3 4 5 6 7

**2.** Watching my partner interfered with my own performance.

1 2 3 4 5 6 7

**3.** I wanted to perform faster than my partner on Day 2.

1 2 3 4 5 6 7

**4.** I controlled the practice schedule (i.e., the order in which my partner and I practiced the cup-stacking task) to benefit my partner's learning.

1 2 3 4 5 6 7

**5.** I controlled the practice schedule (i.e., the order in which my partner and I practiced the cup-stacking task) to benefit my own learning.

1 2 3 4 5 6 7

**6.** I wanted to perform faster than the top 5 pairs listed in the laboratory.

1 2 3 4 5 6 7

**7.** I would have preferred to practice alone.

1 2 3 4 5 6 7

---

*Note*: 1= "not at all true", 4= "somewhat true", 7= "very true"

**Paired Practice Experience Questionnaire – Actor-Controlled Group**

**1.** Watching my partner helped my own performance.

1 2 3 4 5 6 7

**2.** Watching my partner interfered with my own performance.

1 2 3 4 5 6 7

**3.** I wanted to perform faster than my partner on Day 2.

1 2 3 4 5 6 7

**4.** I controlled the practice schedule (i.e., the order in which my partner and I practiced the cup-stacking task) to benefit my partner's learning.

1 2 3 4 5 6 7

**5.** I controlled the practice schedule (i.e., the order in which my partner and I practiced the cup-stacking task) to benefit my own learning.

1 2 3 4 5 6 7

**6.** I wanted to perform faster than the top 5 pairs listed in the laboratory.

1 2 3 4 5 6 7

**7.** I would have preferred to practice alone.

1 2 3 4 5 6 7

*Note*: 1= "not at all true", 4= "somewhat true", 7= "very true"

**Paired Practice Experience Questionnaire – Dyad-Alternate Group**

**1.** Watching my partner helped my own performance.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**2.** Watching my partner interfered with my own performance.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**3.** I wanted to perform faster than my partner.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**4.** I wanted to perform faster than the top 5 pairs listed in the laboratory.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**5.** I would have preferred to practice alone.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

*Note*: 1= “not at all true”, 4= “somewhat true”, 7= “very true”

**Paired Practice Experience Questionnaire – Control Group (P1/actor)**

1. Watching my partner practice the cup-stacking task would have helped my own performance.

   1 2 3 4 5 6 7

2. Watching my partner practice the cup-stacking task would have interfered with my own performance.

   1 2 3 4 5 6 7

3. I wanted to perform faster than my partner on Day 2.

   1 2 3 4 5 6 7

4. I wanted to perform faster than the top 5 pairs listed in the laboratory.

   1 2 3 4 5 6 7

5. I would have preferred to practice alone.

   1 2 3 4 5 6 7

*Note*: 1= “not at all true”, 4= “somewhat true”, 7= “very true”

**Switching Characteristics Questionnaire for the Actor- and Observer-Controlled groups**

1. **When your partner was in control of the practice schedule, do you think they switched roles after the right trials?**
   a) Yes
   b) No
2. **If *NO*, when would you have liked for your partner to switch roles? If *YES*, skip to question #3.**
   a) After Perceived Good Trials
   b) After Perceived Bad Trials
   c) After Perceived Good & Bad Trials Equally
   d) Randomly
   e) Other
3. **When your partner was in control of the practice schedule, how well did their decisions to switch roles facilitate your learning?**

   ***Note: 1= "did not facilitate my learning at all", 4= "somewhat facilitated my learning", 7= "completely facilitated my learning"***

   1 2 3 4 5 6 7
4. **When you were in control of the practice schedule, when/why did you decide to switch roles?**
   a) After Perceived Good Trials
   b) After Perceived Bad Trials
   c) After Perceived Good & Bad Trials Equally
   d) Randomly

e) Other

**5. When you were in control of the practice schedule, when did you NOT decide to switch roles?**

a) After Perceived Good Trials

b) After Perceived Bad Trials

c) After Perceived Good & Bad Trials Equally

d) Randomly

e) Other

**Switching Characteristics Questionnaire for Dyad-Alternate group**

1. **How well did switching roles (i.e., Actor and Observer) after each trial facilitate your learning?**

   ***Note: 1= "did not facilitate my learning at all", 4= "somewhat facilitated my learning", 7= "completely facilitated my learning"***

   1 2 3 4 5 6 7

2. **Would you have liked to have control over when to switch between roles?**

   a) Yes

   b) No

3. **If *YES*, when would you have switched roles? If *NO*, questionnaire is complete.**

   a) After Perceived Good Trials

   b) After Perceived Bad Trials

   c) After Perceived Good & Bad Trials Equally

   d) Randomly

   e) Other

**Switching Characteristics Questionnaire for Control group**

1. **How well would switching roles (i.e., Actor and Observer) throughout practice have facilitated your learning?**

   ***Note: 1= "would not facilitate my learning at all", 4= "would somewhat facilitate my learning", 7= "would completely facilitate my learning"***

   1 2 3 4 5 6 7

2. **Would you have liked to have control over when to switch roles?**

   a) Yes

   b) No

3. **If *YES*, when would you have switched roles? If NO, questionnaire complete.**

   f) After Perceived Good Trials

   g) After Perceived Bad Trials

   h) After Perceived Good & Bad Trials Equally

   i) Randomly

   j) Other

**Partner-Related Version of Perceived Competence Subscale**

1. I think my partner is pretty good at this cup-stacking activity.
   1 2 3 4 5 6 7

2. I think my partner did pretty well at this cup-stacking activity, compared to other students.
   1 2 3 4 5 6 7

3. After working at this cup-stacking activity for a while, I think my partner felt pretty competent.
   1 2 3 4 5 6 7

4. I think my partner is satisfied with their performance at this cup-stacking task.
   1 2 3 4 5 6 7

5. I think my partner was pretty skilled at this cup-stacking activity.
   1 2 3 4 5 6 7

6. This was an activity that my partner couldn't do very well.
   1 2 3 4 5 6 7

*Note*: 1= "not at all true", 4= "somewhat true", 7= "very true"

**Partner-Related Version of Perceived Choice Subscale**

1. I think my partner believes they had some choice about doing this cup-stacking activity.
   1 2 3 4 5 6 7

2. I think my partner felt like it was not their own choice to do this cup-stacking task.
   1 2 3 4 5 6 7

3. I think my partner didn't really have a choice about doing this cup-stacking task.
   1 2 3 4 5 6 7

4. I think my partner felt like they had to do this cup-stacking task.
   1 2 3 4 5 6 7

5. I think my partner did this cup-stacking task because they had no choice.
   1 2 3 4 5 6 7

6. I think my partner did this cup-stacking task because they wanted to.
   1 2 3 4 5 6 7

7. I think my partner did this cup-stacking task because they had to.
   1 2 3 4 5 6 7

*Note*: 1= "not at all true", 4= "somewhat true", 7= "very true

**Appendix I:** Transfer Test Set-Up

**Cup-stacking apparatus set-up for the transfer test.**

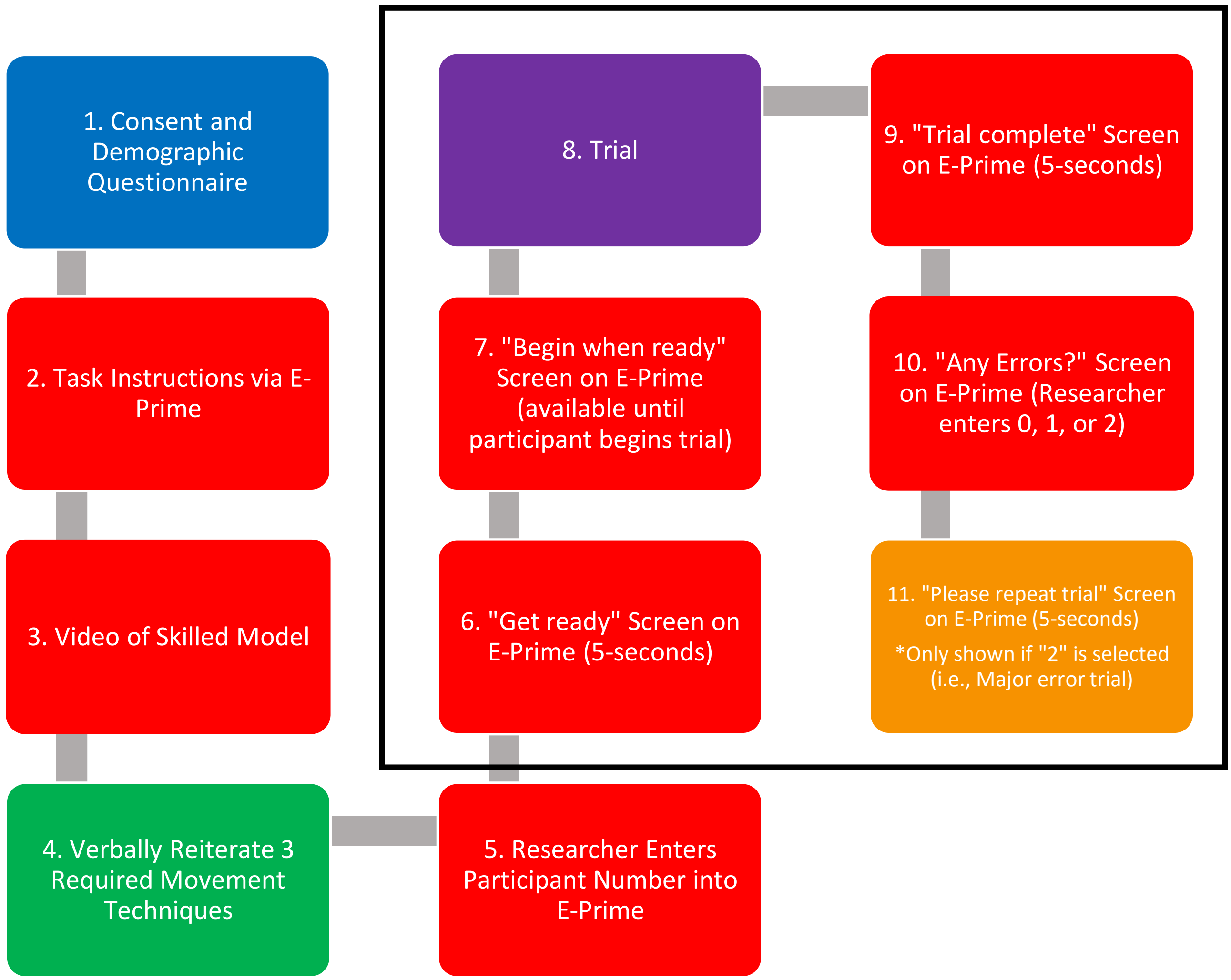
<u>Starting Position</u>

<u>Middle Position</u>

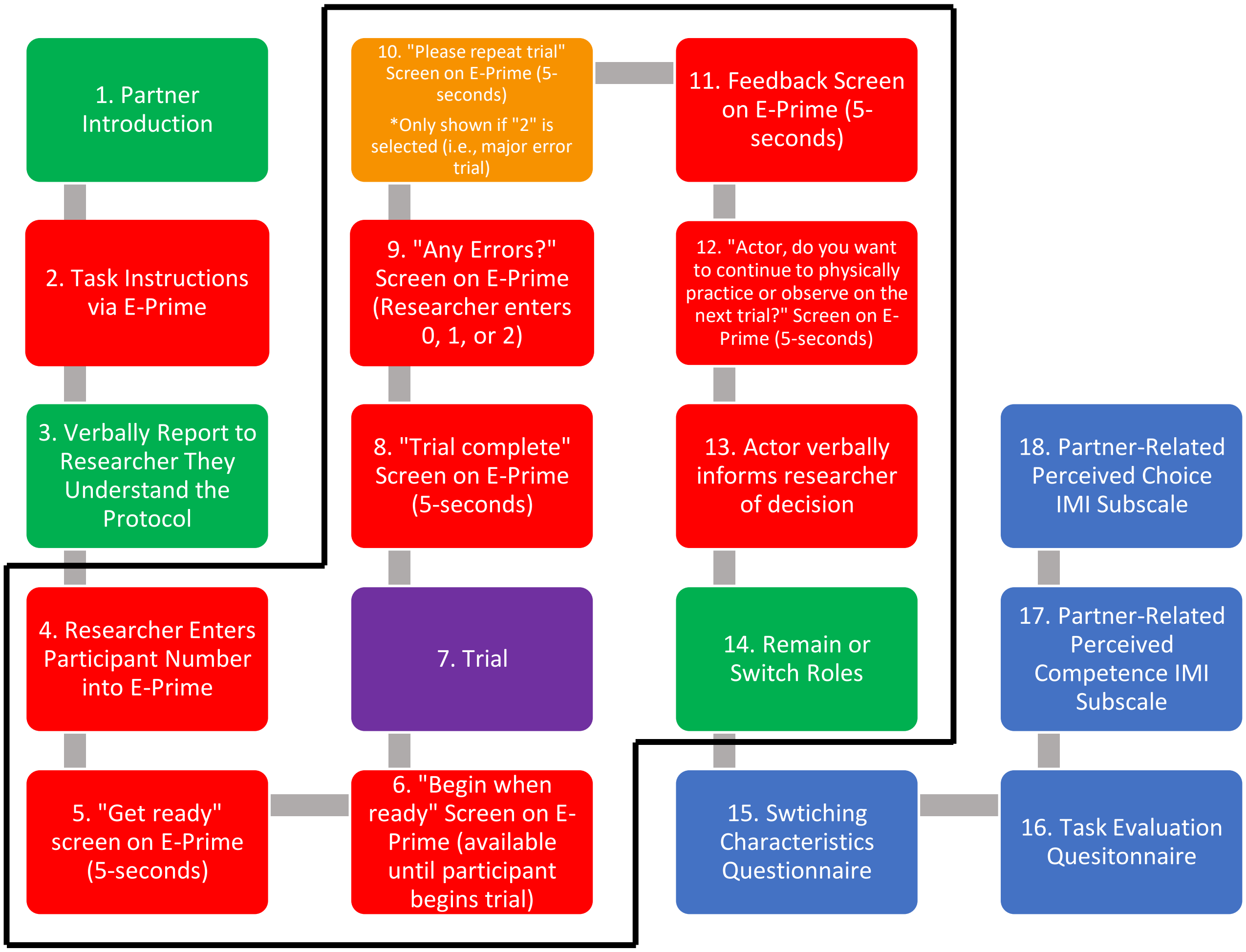
<u>Ending Position</u>

**Appendix J:** Visual Overview of Protocol

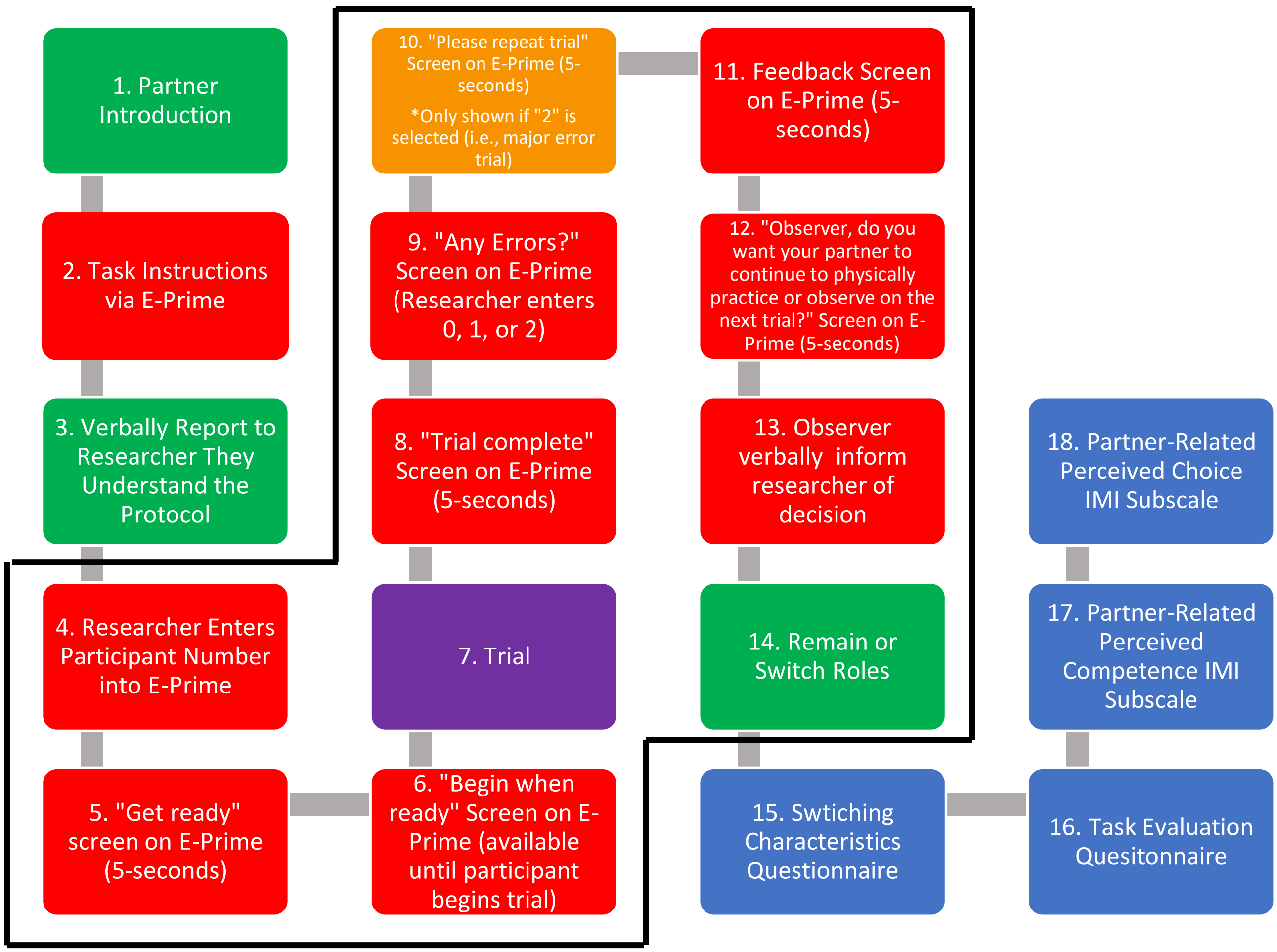
**Experimental Protocol – Pre-Test.** A flow chart describing the experimental protocol followed during the pre-test phase, by all groups. The experimental protocol enclosed in the black square was repeated 5 times (i.e., 5 trials) during the pre-test phase.



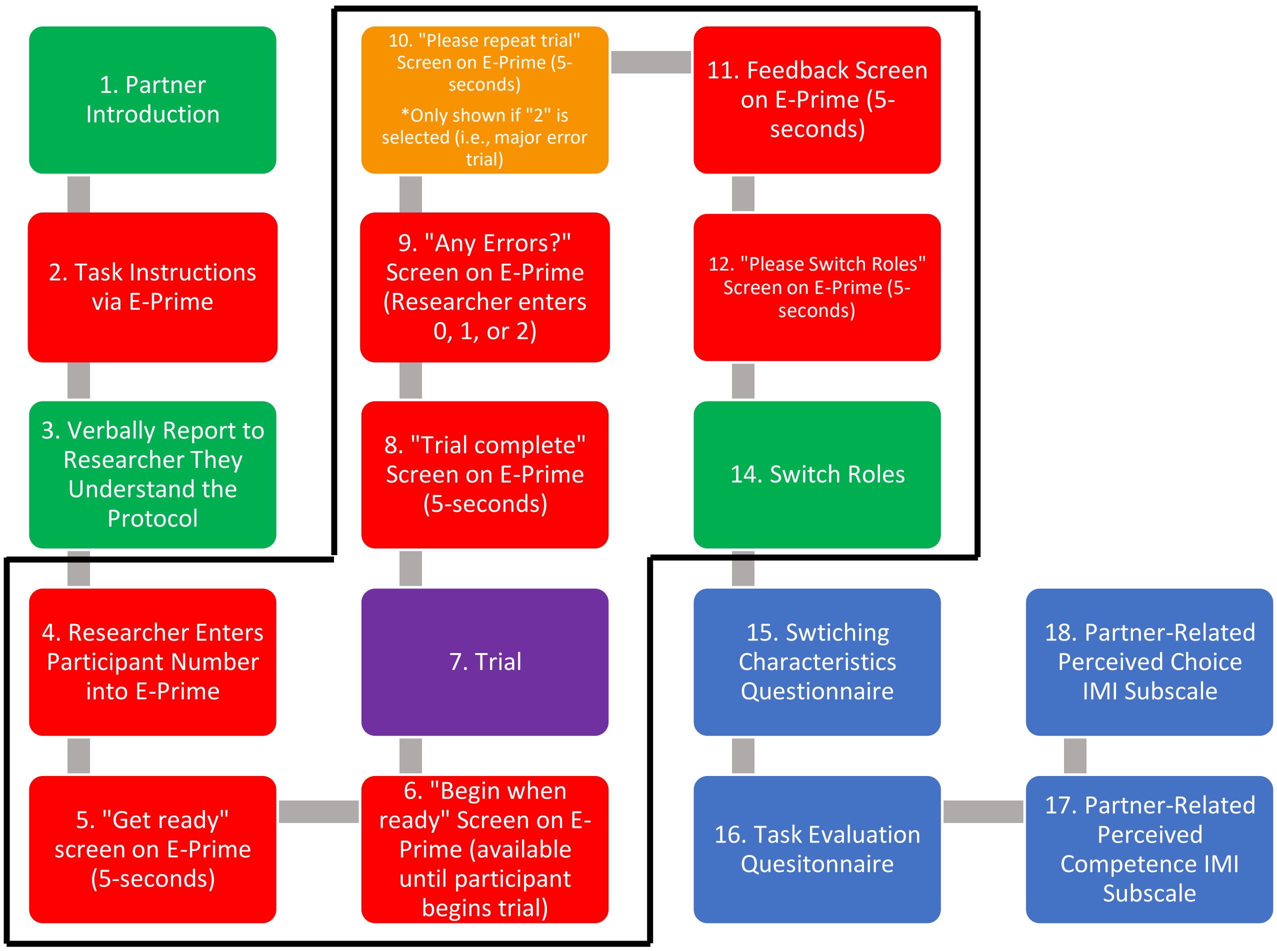
**Experimental Protocol – Acquisition phase, Actor-Controlled Group.** A flow chart describing the experimental protocol followed during the acquisition phase by the Actor-Controlled group. The experimental protocol enclosed in the black box was repeated 40 times (i.e., 40 trials) during the acquisition phase.



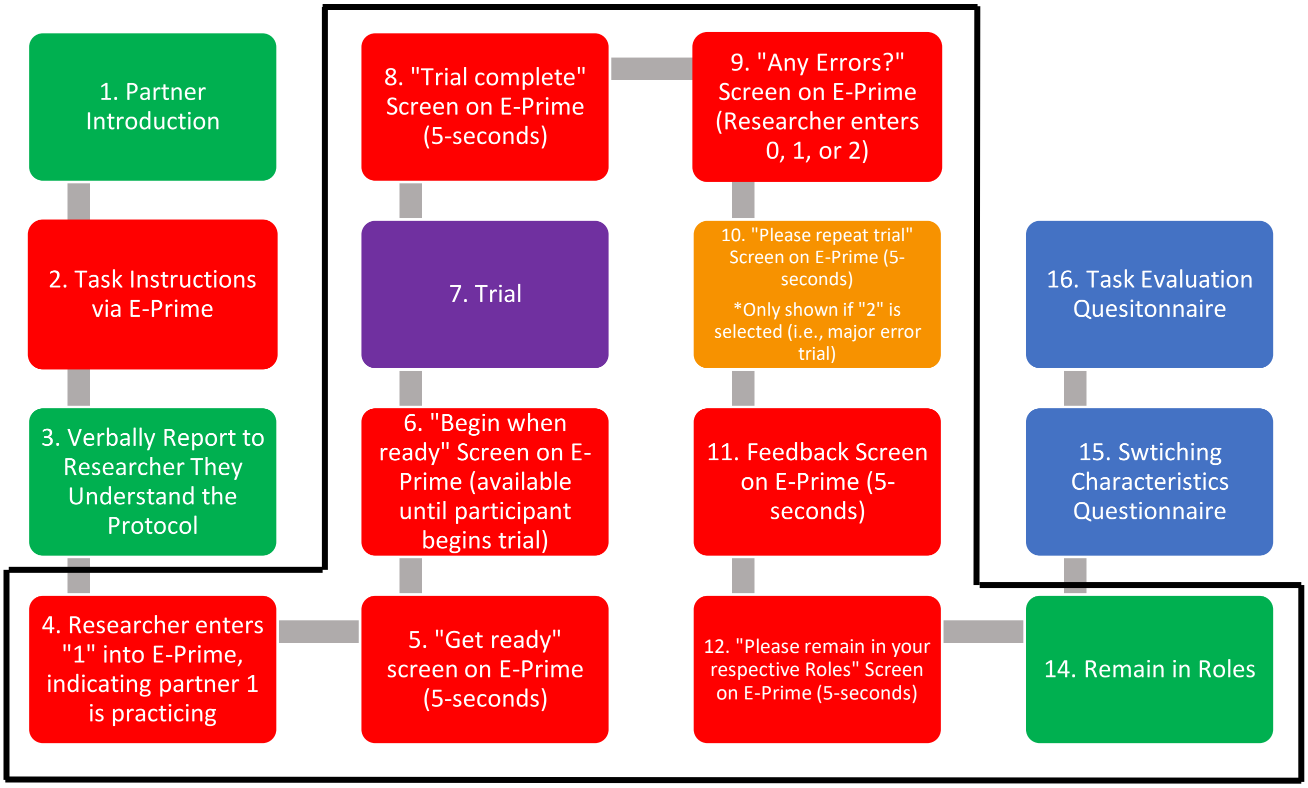
**Experimental Protocol – Acquisition phase, Observer-Controlled Group**. A flow chart describing the experimental protocol followed during the acquisition phase by the Observer-Controlled group. The experimental protocol enclosed in the black box was repeated 40 times (i.e., 40 trials) during the acquisition phase.



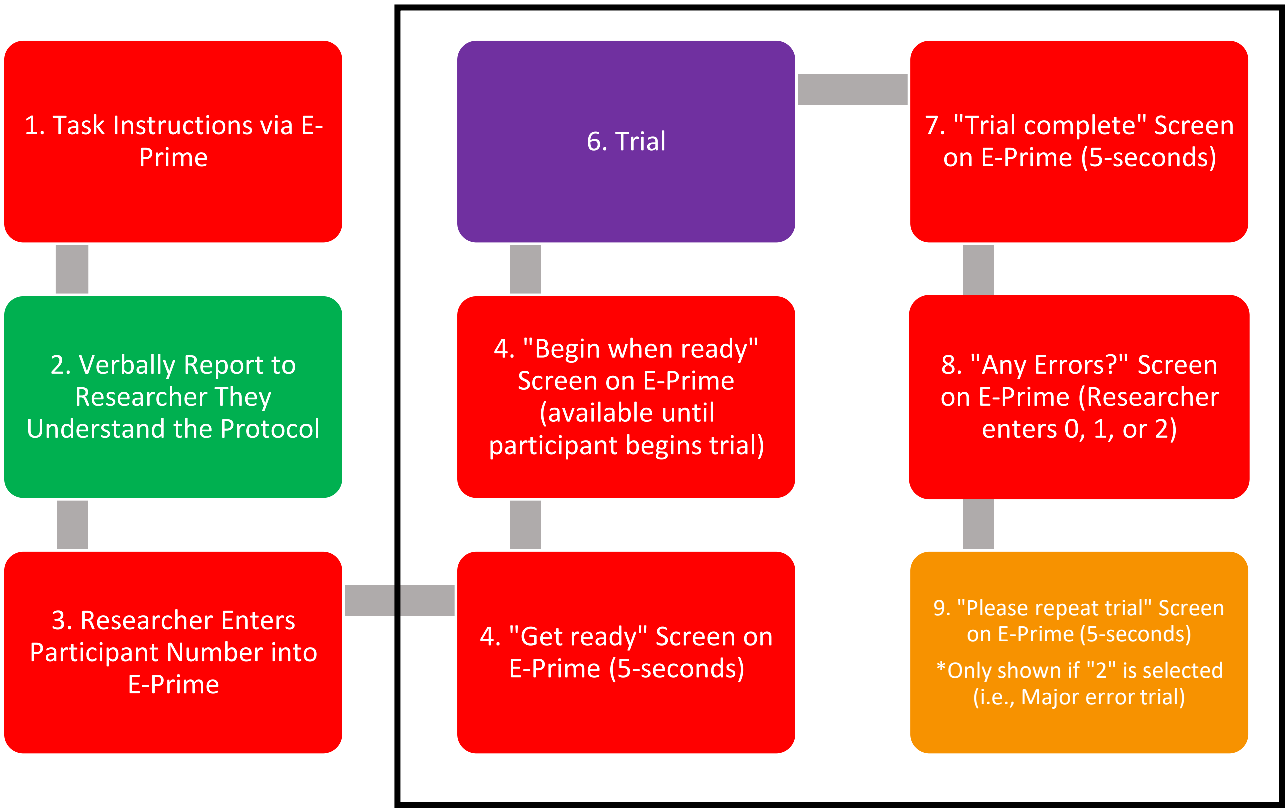
**Experimental Protocol – Acquisition phase, Dyad-Alternate Group.** A flow chart describing the experimental protocol followed during the acquisition phase by the Dyad-Alternate group. The experimental protocol enclosed in the black box was repeated 40 times (i.e., 40 trials) during the acquisition phase.



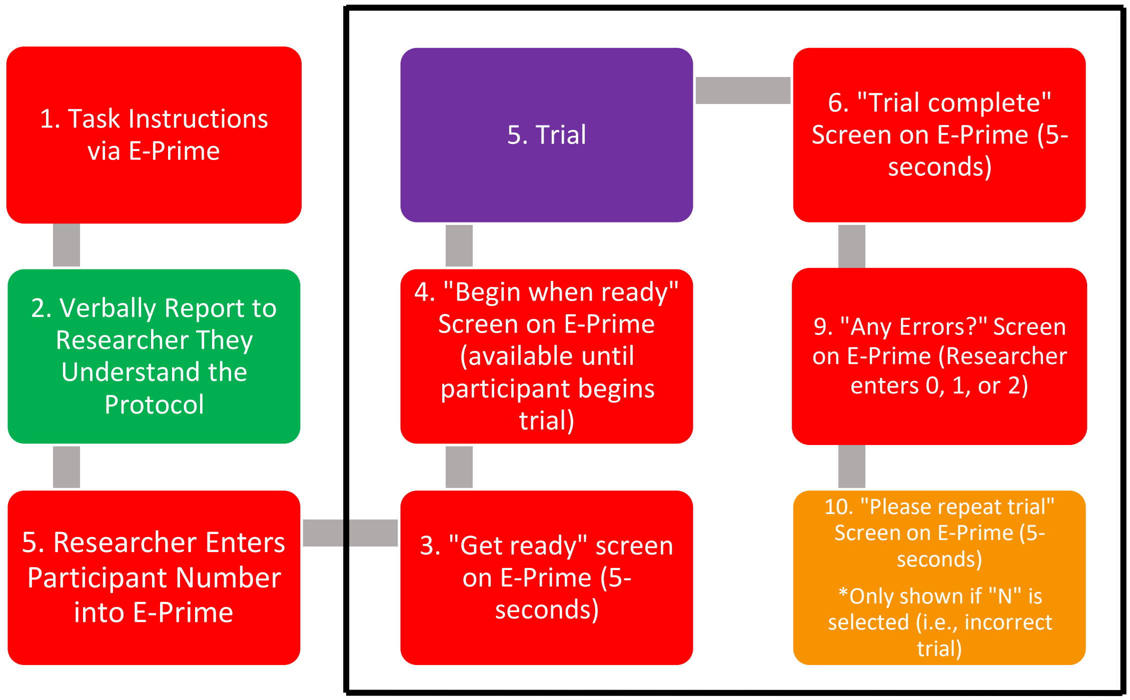
**Experimental Protocol – Acquisition phase, Control Group.** A flow chart describing the experimental protocol followed during the acquisition phase by the Control group. The experimental protocol enclosed in the black box was repeated 40 times (i.e., 40 trials) during the acquisition phase.



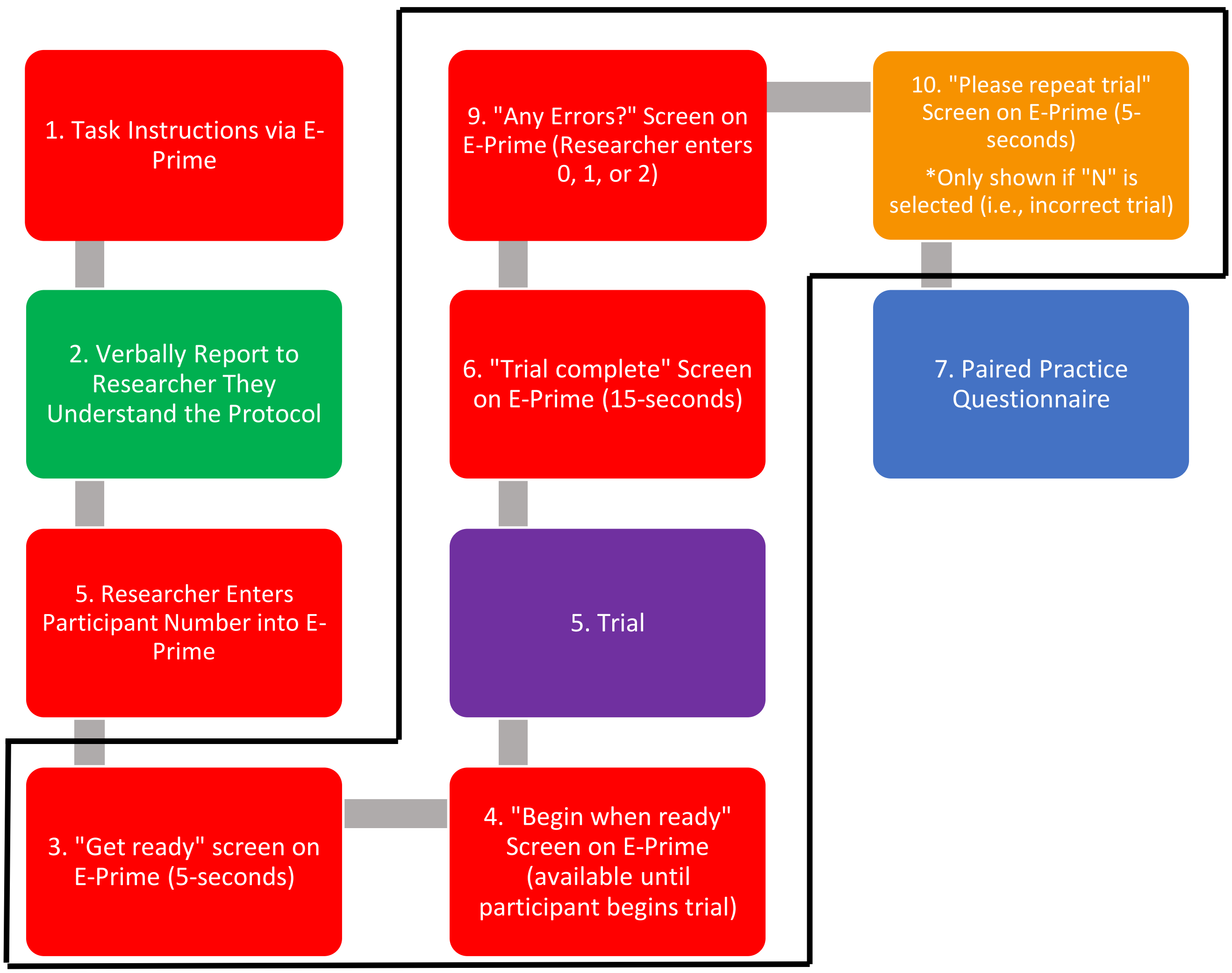
**Experimental Protocol – Post-Test.** A flow chart describing the experimental protocol followed during the post-test phase, by all groups. The experimental protocol enclosed in the black square was repeated 5 times (i.e., 5 trials) during the post-test phase.



**Experimental Protocol – Retention Test.** A flow chart describing the experimental protocol followed during the retention phase of the experiment for all groups. The experimental protocol enclosed in the black box was repeated 7 times (i.e., 2 warm-up and 5 test trials) for the retention phase.



**Experimental Protocol – Transfer Test.** A flow chart describing the experimental protocol followed during the transfer phase of the experiment for all groups. The experimental protocol enclosed in the black box was repeated 5 times (i.e., 5 test trials) for the transfer phase.



**Appendix K:** Informed Consent

Faculty of Applied Health Sciences

Department of Kinesiology

**Participant Information Letter and Informed Consent for Identified Participants**

**Project Title**: Examining an Observer- versus Actor-Controlled practice schedule, within an alternating dyad practice environment.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**INVITATION**
You have been invited to participate in a research study. The purpose of this study is to examine a peer- vs self-controlled practice schedule within an alternating dyad practice environment.

**WHO IS ELEGIBLE**
Brock University male and female students aged 18-25 years, with normal to corrected normal vision. No known motor (i.e., weakness or tremors in hands), or sensory (i.e., numbness or tingling feelings in the hands) deficits that will constrain them from succeeding in the motor task. No previous experience in cup-stacking.

I have normal to corrected normal vision.
I have no known cognitive, motor, or sensory limitations that will constrain success in a motor task.
I have no previous experience in cup-stacking.

If you agree to the above statements, please sign below.

Signature: ________________________________________

**WHAT IS INVOLVED**

Day 1: In the laboratory, you will be required to either physically practice a cup-stacking sequence or observe another participant do so. Dependent on the assigned condition, you and your partner will take turns physically practicing to the task, and observing your partner practice the task. You will be instructed to perform the task as quickly and as accurately as possible, with the overall goal of successfully learning the task. Participants will then be asked to complete 2 questionnaires. (Approximately 60 minutes)

Day 2 (approximately 24 hours after the end of day 1): Participants will return to the laboratory to physically practiced the task for both retention and transfer tests. You will perform 2 warm-up trials of the same cup-stacking sequence they practiced in acquisition, followed by 5 additional trials of that same sequence. You will then perform 5 trials of a different cup-stacking sequence. Following this, you will then be asked to complete a short questionnaire. (Approximately 20 minutes)

**POTENTIAL BENEFITS AND RISKS**

Potential risks for you may include frustration or feelings of defeat involved in the task, as the task will be novel. Further, some participants will have to physically practice the task in the presence of another participant. This could influence your privacy and anonymity. You will be informed to perform to the best of their ability before each practice session. You will also be informed that your cup-stacking success will not have any negative effects on your participation in the experiment, and you can take a break at any time. Furthermore, you will be informed you can withdraw from the experiment at any point without any negative consequences. Involvement of this study will provide you with a further understanding of the different learning techniques relevant to motor skill acquisition. More specifically, you will gain insight to the underlining processes associated with a peer-controlled learning environment and self-controlled amount of practice. For the scientific community, the results of this experiment will address a currently identified gap in knowledge. Specifically, the results of this experiment will offer a novel contribution to both our theoretical and practical understanding of peer-controlled practice and the effects on quantity of practice regarding motor skill learning.

**CONFIDENTIALITY**

A numeric code will be assigned to your initials, so your name will not be associated with the data collected by the computer. All data from the experiment will only be accessed by the Primary Student Investigator and Supervisor and will be on file for a period of five years following publication to allow for publication and dissemination at academic conferences. You will only be listed by your unrelated group identified and number. If referenced in this manner, then the actual code used in publication is typically randomly changed from the one used during the experiment. The order of number assignment is non-sequential, and the group identified is independent of your initials. All data will be stored on a password-protected computer and hard copy forms will be stored in a locked filing cabinet. All hard copy and computer data will be kept for five years (as explained above), post-publication. All information provided will be considered confidential.

**VOLUNTARY PARTICIPATION**

Participation in this study is voluntary. If you wish, you may decline to answer any questions or participate in any component of the study. Additionally, you may withdraw from the study at any time. This can be done by informing the Student Investigator or Supervisor during testing or through email after you have left the laboratory. If you decide to withdraw from the study, the data will be electronically deleted, and consent forms will be shredded immediately following withdrawal. If you decide to withdrawal subsequent to starting the experiment, and have been assigned to a pair group, the data from both you and your paired learner will be electronically deleted, and consent forms will be shredded immediately following withdrawal. Due to social risks of having peers voluntarily participant or choose to not participate in this study, we ask that you please not discuss your experience in this experiment outside of the laboratory.

**PUBLICATION OF RESULTS**

Results of this study may be published in professional journals and presented at conferences. Feedback about this study will be available to you and be obtained from Dr. Jae Patterson who can be contacted through the information listed above. Additionally, individual feedback will be available approximately 4 months following the end of the study, upon request.

**CONTACT INFORMATION AND ETHICS CLEARANCE**

If you have any questions about this study or require further information, please contact Dr. Jae Patterson from Brock University with the information provided above. This study has been reviewed and received ethics clearance through the Research Ethics Board at Brock University 18-201-PATTERSON. If the participant has any comments or concerns about their rights as a research participant, please contact the Research Ethics Office at (905) 688-5550 Ext. 3035, reb@brocku.ca.

**INFORMED CONSENT TO PARTICIPATE**

I agree to participate in the study described above. I have made the decision based on the information I have read in the Information-Consent Letter. I have had the opportunity to receive any additional details I wanted about the study and understand that I may ask questions in the future. I understand that I may withdraw this consent at any time.

Name: ______________________________ Witness: ____________________________

Signature: ___________________________ Signature: ___________________________

Date: _______________________________ Date: _______________________________

E-mail: ______________________________