THE INFLUENCE OF FALSE FEEDBACK ON THE ACTION SPECIFIC EFFECT IN NOVICE MOTOR SKILL PERFORMANCE

By

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Lay Abstract

When performing well, targets (e.g. baseball, golf hole) are perceived as larger, and vice versa. Using a mini-putting task, this thesis investigated whether it was only true performance that can lead to this effect.

In the first experiment, participants compared their own performance to the fake performance reports of others. How difficult they felt the task to be – instead of their own scores - affected their perceived hole size. In the second experiment, their golf balls were either secretly moved closer or further from the target (regardless of their actual scores). It was found that as the number of errors increased, the perceived target size also increased.

This contributed to research by showing that comparing performance to others can change what one uses to judge performance, and that when visual results do not reflect ones actions, the bias in perceived target sizes can be eliminated, or reversed.

Abstract

Recent golfing performance influences target size perception, regardless of long-term ability (Witt, Linkenauger, Bakdash, & Proffitt, 2008). Better performance was correlated to larger perceived golf hole sizes than poorer performance. The present thesis used falsified feedback for a mini-putting task to help determine the requirements of this effect.

Participants in Experiment 1 viewed their true trial-by-trial performance, but after two blocks of trials, was given feedback in the form of comparison to others (i.e. social comparative feedback). Regardless of their true performance, those in the positive feedback group were told they performed better than others, and those in the negative feedback group performed worse. Target size perception was found to correlate with ratings of task difficulty as opposed to radial error. Because this correlation was not found before feedback manipulations were given, it was suggested that trial-by-trial performance was no longer a strong influencer on target size perception. Instead, the perceived difficulty of the task influenced it.

The second experiment completely dissociated motor action from performance outcome. Occlusion goggles and a headset that played white noise activated such that participants were not able to view the resulting movement of their golf ball after their putter came into contact with it. The ball was secretly moved to a predetermined location – closer (positive feedback participants), or further (negative feedback participants). Target size estimations increased as the number of errors and difficulty ratings increased. This was contrary to Witt et al.'s (2008) findings.

Since various limitations and confounds could be resolved by running these experiments in an open field, it would be valuable to run them again. This thesis sought to contribute to research by taking the first steps to investigating whether the action specific effect is driven by top-down or bottom-up processes.

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Afrisa

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List of all Abbreviations and Symbols

IQR ……….. Interquartile Range

KR ………… Knowledge of Results

OO ………… Overshoot trial followed by overshoot trial

OU ………….Overshoot trial followed by undershoot trial

UO ………….Undershoot trial followed by overshoot trial

UU ………….Undershoot trial followed by undershoot trial

Declaration of Academic Achievement

The following is a declaration that the content of the research in this manuscript has been completed by Afrisa Yeung with contributions from Dr. James Lyons, Dr. Lawrence Grierson, Dr. Elizabeth Sanli, Dr. James Roberts, Dr. Brian Richardson, Kinga Eliasz, Jessica Cappelletto, Erin Brunato, Raquel Burgess, and Jessica Skultety.

Afrisa Yeung was responsible for data collection, data analysis, and the writing of the manuscript.

Dr. James Lyons created the original study design, assisted with the data analysis, and thoroughly reviewed the manuscript.

Dr. Lawrence Grierson and Dr. Elizabeth Sanli provided valuable advice and reviewed the manuscript.

Kinga Eliasz, alongside Dr. James Lyons, created the original study design, and provided insightful advice with regards to data analysis.

Dr. Brian Richardson created the MATLAB program and computer set up for the computer size-matching task.

Erin Brunato was responsible for all aspects of the pilot study: data collection, data analysis, and the write up of the manuscript for the pilot study. Afrisa Yeung helped her with data collection.

Because the procedure of the experiments required a second set of hands to operate lab equipment, the following individuals had generously volunteered to help in data collection: Dr. James Roberts, Dr. Brian Richardson, Jessica Cappelletto, Raquel Burgess, and Jessica Skultety.

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1.0 Introduction

1.1 The Action Specific Effect

How well one is performing a motor skill has been shown to affect their perception of that skill. For example, baseball players who were performing well have likened the baseball to the "size of a grapefruit", and when they were performing poorly, the baseball was more like "a black eyed pea or an aspirin" (Witt & Proffitt, 2005). In golfing, players described the cup as "a bucket" (Witt and Dorsch, 2009). This phenomenon, called the action specific effect, was defined by Witt (2011) as the influence of the perceiver's abilities on the perception of the target object or environment. For instance, a parkour athlete might perceive a wall as more climbable, and therefore shorter, than how novice participants would perceive it (Taylor, Witt, & Sugovic, 2011).

Action specific effect studies postulate that performance influences perception in a subjective manner (e.g. target size may appear larger or smaller than it truly is). This is different from the traditional view of the relationship between motor performance and perception, which is that performance improves (decreased movement time, increased accuracy) as the objective tolerance for error (e.g. target size) increases (Fitts, 1954). However, past studies using illusions have shown that it is possible to "trick" the sensory system into incorrectly perceiving target sizes. These illusions could also influence behaviour (Mendoza, Hansen, Glazebrook, Keetch, & Elliott, 2005; van Donkelaar, 1999). Mendoza and colleagues (2005) used a variant of the Ebbinghaus Illusion in a target aiming task to explore whether the "perceptual" size of a target resulted in performance effects similar to those of the real size of the target. Specifically, when a target circle is surrounded by circles (annuli) that are *larger* than itself, it appears smaller than its true size and conversely, when surrounded by circles that are *smaller* than itself, it appears larger than its true size. Mendoza and colleagues (2005) found that when participants moved their finger to the center target of an Ebbinghaus illusion target as quickly and accurately as possible, movement time increased when the target circle was surrounded by large annuli (i.e. it appeared smaller than it actually was, and therefore the tolerance for error was lower) compared to when the target circle appeared larger because it was surrounded by smaller annuli (Mendoza et al., 2005; see also van Donkelaar, 1999). This is consistent with Fitts' Law, which says there is a trade-off in speed when the tolerance for error is decreased (e.g. smaller target sizes) (Fitts, 1954). Thus, goal-directed aiming studies using illusions suggest that the Fitts' Law speed-accuracy relationship applies even when the true size of a target is incorrectly perceived (Mendoza et al., 2005; van Donkelaar, 1999). This suggests that the changes in target size perception as found in action specific effect studies might also alter the perception of error tolerance and, as suggested by Fitts' Law, will influence behaviour (e.g. slower, more deliberate movements if the target appeared smaller). So, while goal-directed aiming studies that have illusions investigated whether incorrect perception of target sizes influenced behaviour (e.g. change in speed), action specific effect studies investigated whether behaviour (e.g. better abilities) influenced incorrect perception of target sizes.

Thus there is some evidence that, at least in target aiming studies, the perception of how possible actions are represented in the motor system depends on the perceiver's abilities since these abilities can affect moment to moment perception of the object or environment. Further evidence in this vein comes from a compelling series of studies by Witt and colleagues wherein similar perceptual biasing effects found in illusion studies are revealed in the presence of non-illusory stimuli. For example, Witt and Dorsch (2009) had participants estimate the width and height of football uprights after having attempted kicks into it. They found that those who were more successful at their kicks estimated the uprights to be shorter and farther apart than those who were less successful. Similarly, after playing a game of softball, Witt and Proffitt (2005) had participants rate the size of the softball by pointing at one of a series of black circles that ranged in diameter. Participants who had played a better game rated the softball to be significantly larger than those who played a poorer game. In golfing, Witt et al. (2008) asked golfers to point to the black paper circle (out of 9) that was closest to the size of the golf hole immediately after they completed a round of golf. A correlation found that those who played better that day perceived the golf hole to be significantly larger than its actual size - regardless of actual long-term player ability. Because the experimenters were uncertain as to whether recent performance affected remembered golf hole size or perceived golf hole size, they conducted two follow up experiments that differed from each other only in the target size perception task. Participants (university students) made 10 putts either from a distance of 2.15 m away from the golf hole (hard condition), or 0.4 m away from the golf hole (easy condition). To investigate the influence of performance on remembered golf hole size, participants went to a separate room and drew a black circle on Microsoft Paint to best replicate the golf hole to which they had aimed. Participants in the easy condition drew the hole to be significantly larger than those in the hard condition. One limitation that

Witt et al. (2008) addressed in their second follow-up study was that because those in the easy condition putted from a shorter distance, their visual angle of the target was different from those in the hard condition. Thus, by having participants in both conditions sit in the same location beside the golf hole and allowing them to look at the golf hole while they made their size estimations, they minimized the effect of differing visual angles, and investigated if performance influenced perception (as opposed to remembered golf hole size). Again, they found that those in the easy condition estimated the golf hole to be larger than those in the hard condition. This could potentially be due to memory distortions. Although participants sat beside the target and were allowed to view it while they made their size estimations, those in the hard group had spent more time throughout the duration of the experiment viewing it from a further distance (and therefore the target appeared smaller) than the easy group (and therefore the target appeared larger to them). This limitation could be overcome if difficulty were manipulated in a way where visual angle was not affected (e.g. bump along the green, varying putter or golf ball weights).

Because significant size estimation biases were found with recent performance and not overall performer ability in the previously discussed studies, it was supported that recent performance influenced perception. However, the direction of causality (whether better putters perceived the hole as larger, or whether perceiving the hole as larger allowed individuals to putt better) was still unclear.

Witt's follow-up experiment (Witt & Dorsch, 2009) investigated the direction of causality. After a few practice kicks of a football towards a net, participants were brought in front of a field goal post and asked to estimate the size of it using a mock upright apparatus. They were able to adjust the width and height while viewing the real uprights. Participants then kicked 10 field goals before immediately estimating the size of the uprights with the mock upright apparatus for a second time. This within participant procedure allowed the experimenters to investigate whether their original target size estimations influenced subsequent performance, or whether their recent performance influenced target size estimations post-performance. After kicking to the actual uprights, those who performed better perceived the uprights as further apart and shorter than those who performed worse. However, they found no perceptual differences between the two groups before they kicked to the actual uprights. If the direction of causality was that original perception influenced performance, then participants who later performed better would have initially perceived the uprights as further apart and shorter. Since this was not the case and perceptual biases occurred after performance, there was support for the direction of causality to be recent performance influencing perception.

Although the participants in Witt and Dorsch's (2009) study were novices, some may have learned the motor skill more quickly, and advanced to another learning stage sooner. The Three Stages Model by Fitts and Posner (1967) describes the stages learners progress through while acquiring a novel motor skill. The first is the *Cognitive Phase*, named as such due to the large demand for attention and thinking required to understand the task. During this stage, it is useful for the educator to direct attention to relevant perceptual cues. Movements tend to be jerky and uncertain, and numerous errors occur (Schmidt & Wrisberg, 2008, pp. 200 - 201). Once learners achieve a general idea of the novel movement, they progress into the *Associative Phase*, where they focus on improving and refining their movement patterns. Movements become more consistent, the amount of errors and demand on attention decrease, and improved self-monitoring of feedback allows for better error detection. Learners become more able to use cues from the environment to help anticipate and time their movements. The final stage is the *Autonomous Phase*, although not all learners will reach it. This stage describes learners who have reached the highest proficiency in the skill, wherein their actions occur with minimal attention. Instead, attention is directed to changes in environmental cues and the creation of strategies to adapt to these changes. With respect to the action specific effect, expertise did not appear to be a significant factor (perceptual bias was not significantly different between novices and experts) (Memmert, Blanco, and Merkle, 2009). Memmert et al. (2009, Experiment 1) had golfers point to a board with 8 differently sized golf balls to indicate which they believed to be the correct size before and after a golf tournament. During data analysis, participants were separated into the skilled and less-skilled players using handicap values as their determining factor. They found that expertise did not influence perceived golf ball size. The authors suggested that this may be because experts have not been shown to have better basic visual perceptual abilities (Williams, 2002).

Although expertise is not required for the action specific effect to occur, some aspect of recent performance influenced perception. Foerster, Gray, and Cañal-Bruland (2015) sought to determine whether it was the number of successful trials (e.g. hitting the target), or the variability in performance (e.g. not hitting the target but consistently landing close to it). Using a hidden magnetic bar, the experimenters altered participants' results on an adapted shuffleboard task such that the constant error was the same between conditions, but the variable error (i.e. the variability in performance) was different. To do this, the magnetic bar was placed at predetermined distances far away from the target (high variable error), or close to the target (low variable error). Constant error between the groups were close to identical by having the magnetic bar situated an equal number of times in front of, or behind, the target. Foerster et al. (2015) predicted that those with a low variable error would estimate the target to be larger than those with a high variable error. Because they found no significant differences in target size estimations between the variable error conditions, they concluded that perception of target size was not likely influenced by the variance component in performance. The authors suspected that participants may have noticed inconsistencies between their actions and the outcomes.

The action specific effect is not only constrained to the individual performing the actual task – it can occur when observing others perform too. Bloesch, Davoli, Roth, Brockmole, and Abrams (2012) found that although the observer's own reaching ability hadn't changed, they perceived targets as closer to the performer when they observed someone reaching for the targets while using a tool compared to when they weren't using a tool. Balls also appeared to move more slowly when participants observed another individual using larger paddles than smaller paddles (Witt, Sugovic, & Taylor, 2012). Witt, South, and Sugovic (2014) sought to determine whether these effects were influenced more by the observer's own abilities, or the observed individual's abilities. Participants arrived in pairs. One participant would play a game of pong, while the other observed. At the end of every trial, participants estimated the speed of the ball. Once the experiment was complete, participants switched roles, and completed the experiment a second time. As suggested from previous experiments, participants who were better at blocking the ball perceived the ball as moving more slowly than those who were worse. Interestingly, as observers, those whose partners performed worse than them still perceived the ball to be moving more slowly, which better reflected the abilities of the observer. Thus, Witt et al.'s (2014) findings suggested that even as an observer, the participant's own abilities influenced perception.

Aside from the inherent ability of the perceiver, factors such as mood and contagion can also influence perception. Riener, Stefanucci, Proffitt, and Clore (2011) found that mood can affect the perception of slant. Mood was induced by having participants write about a very positive or negative experience. After completing their drafts, participants went outside the laboratory to complete the perceptual task on the slant of a hill. Those in a negative mood reported the hill to be steeper than those in a positive mood. One possible explanation was the effect of mood on attention. Riener et al. (2011) said that those in a happier mood attended to foreground objects more than sad individuals, and sad individuals attended more to background objects. In the case of perceiving the slant of a hill, sad participants may have looked further into the background to the top of the hill, which may have caused it to look steeper. Happy participants may have looked at the foreground, which would be lower on the hill and thus it looked less steep.

Lee, Linkenauger, Bakdash, Joy-Gaba, and Proffitt (2011) showed that contagion, defined as the transfer of positive or negative properties from one object (usually animate) to another object as a result of coming into contact with each other, can influence perception as well. They induced positive contagion by informing participants that Ben Curtis, a well-known Professional Golfers' Association Tour athlete, had in the past, used the same putter they were to use in the experiment. To determine if positive contagion alone had an effect on perception, participants immediately viewed and drew the golf hole before completing any putting trials. As Lee et al. (2011) had predicted, participants who received the positive contagion manipulation perceived the golf hole to be bigger before putting, and had also performed better by sinking more putts than the control group (who received no contagion information). Lee et al. (2011) offered a few explanations for their findings. Firstly, they suggested that imagining oneself performing well before a sports competition has been positively correlated with performance. Being informed that Ben Curtis had used the same putter as them may have induced positive imagery in participants. Secondly, participants may have been primed to think about skill mastery when discussing Ben Curtis. Finally, positive contagion can be viewed as having a placebo effect. By learning that someone with high expertise used the same putter that they will use, participants may have imparted more value (e.g. luck) to the putter.

1.2 Mechanisms behind the Action Specific Effect

Various mechanisms have been proposed as explanations for the occurrence of the action specific effect. The first is response bias, which suggests that perception did not change with performance, but actually that participants were trying to comply with what the experimenter might be hypothesizing. For example, Durgin, Baird, Greenburg, Russell, Shuaghnessy and Waymouth (2009) performed an experiment that found effort to influence perception through a paradigm where participants either wore a heavy or light backpack, and then estimated hill slant. It was possible that participants deduced the relationship between the task of wearing a heavy backpack, and the task of estimating hill slant – that the experimenter was hypothesizing a heavier backpack was related to steeper estimations of slant – and complied with it. Witt and Sugovic (2013) provided support against this potential hypothesis. They had participants complete a ball-blocking task on a computer using varying paddle sizes (i.e. varying blocking difficulty). After every trial, participants had to rate the speed of the ball as fast or slow. One group was specifically instructed to classify the slow balls as slow, and the other group was instructed to classify the fast balls as fast. During data analysis, participants were separated into a compliant group (followed the instructions) or non-compliant group (didn't follow the instructions). If the response bias explanation was correct, then non-compliant participants should not exhibit a perceptual bias for the speed of the ball (e.g. faster when the paddle was smaller). If it was not correct, then both groups of participants should exhibit the action specific effect. The results showed that both groups of participants perceived the ball as faster when the paddle was smaller. Thus the action specific effect occurred even when participants were non-compliant. That is, response bias may potentially explain the perceptual biases found in action specific effect experiments, but not reliably.

Another explanation for the findings in action specific effect experiments is that it was actually memory of the target size that was being measured, and not perception. Generally, participants estimated target sizes after completing the motor task using some variant of a visual matching task. As such, they were not looking directly at the target and thus relying on memory. Even in paradigms where participants sat next to the target (e.g. Witt et al., 2008) or had a direct view of the target (e.g. Witt & Dorsch, 2009), they still had to remember the size of the actual target when they looked away and to the target size estimation apparatus (Cooper, Sterling, Bacon, & Bridgeman, 2012). Cooper et al. (2012) investigated whether performance influenced memory or perception in their experiment using a task where participants threw a marble into a hole. Participants either made a target size estimation before the throw while the hole was visible (control condition), immediately after throwing while the hole was still visible (perception condition), or after the throw while the hole was not visible (memory condition). Estimation of the target was accomplished proprioceptively, by indicating the diameter between the index and thumb fingers. Participants were not able to view their estimating hand, allowing them to maintain attention on the target during the estimation. Each trial was categorized as either a successful throw, or an unsuccessful throw. It is important to note that size estimations occurred for every trial, because one criticism of Witt's series of studies (Witt & Dorsch, 2009; Witt et al., 2008; Witt & Proffitt, 2005) was that the biases they found in target perception might have actually been related to just the performance in the last trial, as opposed to over a series of trials. That is, those who performed better over a series of trials were more likely to have a more successful last trial, and those who performed poorly were more likely to have a less successful last trial. By having participants estimate the target size for every trial, Cooper et al. (2012) were able to analyze biases for each recent performance as opposed to after a series of trials where a variable number of successes and failures had occurred. They found a significant difference in size estimations between successful and unsuccessful trials in the memory condition only. This suggested that performance affected the memory of the target, as opposed to the perception of the target. This was an important consideration, as a number of previous experiments did not properly isolate perception from memory. This could mean that past instances of the action specific effect were really cases of memory distortion.

A third possible explanation is visual attention. Cañal-Bruland, Zhu, van der Kamp, and Masters (2011) ran a series of 3 experiments of varying amounts of visual information using mini-putting as the main motor task, and target size estimations as the main perceptual task. In their first experiment, participants completed the target size estimation task after their first successful trial, and after the completion of their last trial. They were allowed to view the actual target as they drew their estimation on Microsoft PowerPoint. The number of putts that successfully landed in the target was significantly positively correlated to target size estimations. In their second experiment, they removed visual feedback by placing a curtain between the participant and the target (thus also preventing visual attention). Participants were however, allowed to view the target before the first trial, after the first successful hit, and after the final trial. They completed the target size estimation after the latter two viewings. Other than those three instances, participants were only provided verbal feedback (e.g. “too short”). They found no significant correlations between performance and target size estimations. Finally, in their third experiment, they introduced an intermediate task: they had to putt through a gap into the target circle. In this way, visual attention was divided between the gap and the target circle. Again, they found no significant correlations. Thus, Cañal-Bruland et al. (2011)

showed that the knowledge of results (their second experiment) was not enough to bias perception. Visual attention in particular, must be specifically focused on the target in order for the action specific effect to occur. This finding may be due to the perceptual accentuation hypothesis, which states that an individual's intention to act upon an object causes that object to stand out (e.g. larger in size). Thus, when the target was not in view (their second experiment), or when the target was a secondary goal (their third experiment), perceptual accentuation cannot occur – the action specific effect was absent.

In conclusion, there are various possible explanations as to why the action specific effect occurs, but many questions still remain. Previous studies on the action specific effect discussed until this point allowed participants to view the quality of their own recent performance as a result of their actions (e.g. home runs, higher scores). Could perception be influenced by manipulating one to believe they were performing well (or poorly)?

1.3 Experimental Manipulations to Encourage Internalization of Success

Feedback provided as knowledge of results (KR) is important for learning a novel motor skill (Wulf & Shea, 2004). KR is defined as information given to the learner regarding their performance relative to their goal. Numerous studies have been conducted to determine the most beneficial way to use KR in supporting learning. For instance, although there was no difference in performance during the acquisition of a motor task between those who received immediate KR and those who received it 8 seconds after the end of a trial, performance during retention was worse for those who received immediate

KR (Swinnen, Schmidt, Nicholson, & Shapiro, 1990). Park, Shea, and Wright (2000) further found that the best way to provide feedback (as shown by the lowest amount of retention errors) was to periodically withhold it. Both of these strategies were speculated to encourage the learner to depend less on feedback, and to seek other sources of information regarding their performance (e.g. internal cues from kinesthetic feedback).

While these studies have shown that providing a few seconds delay or trials with no feedback will allow the participant to better learn and reflect on their most recent performance, another way to use feedback is to provide the participant with falsified results. Lewthwaite and Wulf (2010) had participants stand on a balancing apparatus that can sway side to side, and they were to maintain it in a stable horizontal position for over a minute. The experimenters provided false positive feedback (that participants performed better than they really did), false negative feedback (that participants performed worse than they really did), or control feedback (their absolute score was provided) after every trial. Those in the false positive feedback group acquired the skill significantly better than those in the false negative feedback or control group. This finding provided support that the belief of ability in one's performance can impact the acquisition of a novel skill. The mechanisms behind this relationship could be enhanced expectancy, and an increase in feelings of self-efficacy.

Self-efficacy is defined by Bandura (1977) as an individual's belief in their ability to successfully achieve a goal. Perceived self-efficacy can affect behaviour related to the task from the beginning to the end. For instance, with regards to initializing the activity, individuals tend to avoid ones they feel aren't within their capabilities, and participate in those that they feel are. During the activity, self-efficacy influences the amount of effort and time people will spend when issues arise. Thus, false feedback that successfully affects self-efficacy can in turn affect performance by increasing or decreasing motivation.

Bandura (1977) describes four sources of self-efficacy. *Performance accomplishments* refers to the learner's personal history of successes with the task. Whereas successes will improve perceived self-efficacy, failures will decrease it. The detrimental effects of failures may be overcome by successes as a result of persistence. *Vicarious experience* is observing others doing the same task. For instance, watching someone complete an initially threatening task without any harmful effects may encourage the learner to attempt or persist in practicing. When learners are convinced they are able to complete a task by someone telling them they can, self-efficacy was influenced by *verbal persuasion*. However, both vicarious experience and verbal persuasion are weaker sources of self-efficacy than performance accomplishments because they don't directly reflect or build upon the learner's past experiences with the task. *Emotional arousal* is the fourth source of self-efficacy. Learners experiencing high degrees of negative arousal may not expect success as much as those experiencing less negative arousal. For instance, Bandura (1977) suggested that fear of their own incompetence may increase a learner's anxiety to a level above the anxiety they will feel during the actual performance of the feared task. Such high levels of fear suggest that their expectation of success is very low.

Self-efficacy has been shown to be affected by false feedback. Hu, Cheng, Lu, Zhu, and Chen (in press) investigated whether the enjoyment of physical activity could be influenced by manipulating beliefs in self-efficacy. Participants' levels of self-efficacy were measured before and after a test that assessed their levels of fitness. The results of the fitness test were falsified. Those falsely told they were not as fit had a lower self-efficacy post-fitness test, and subsequently didn't enjoy physical activity as much as those who were falsely told they were fit. These findings were expected because verbal persuasion (false results regarding ones level of fitness) and, if the falsified results were believed, performance accomplishments (a result indicating a high level of fitness was positive information) were two factors from the false feedback that influenced self-efficacy (Bandura, 1977). Thus, false feedback can influence self-efficacy.

Past studies that investigated the action specific effect provided true KR for their participants. False feedback can be used to induce an illusion of a successful (or unsuccessful) performance regardless of true performance. Ford, Williams, and Hodges (2007) had skilled soccer players kick a ball over an opaque barrier to land in a target area. Vision and hearing were occluded such that they had no access to true KR. Pre-recorded videos of a soccer ball moving over the barrier and into the target area were used to provide false KR. The goal in the cover story was to aim for a target on the other side of the barrier. Thus, the videos used for false KR reflected participants' actual scores with regards to landing on the target. However, the clearance of their shots over the barrier were lower than their actual shots for the erroneous feedback group, and unchanged for the correct feedback group. Although the goal of the task was to have the ball land in the target area and the videos reflected their true scores, erroneous feedback participants showed higher kicks after false feedback suggested that their clearance over the barrier was less than it actually was. This study showed that although KR was falsified on a lower priority task (e.g. clearing the barrier), participants still experienced an illusion of less successful kicks and adapted their behaviour by kicking the ball higher. A possible explanation for this finding could be due to visual attention: because the barrier blocked the target area from view, participants had to focus on the barrier itself.

A limitation with using false KR is that it can be difficult to know if the illusion is effective. That is, whether the participant actually believes they are performing worse (in the case of Ford et al. (2007)), or whether they simply adapt to the task (e.g. they notice the feedback is always worse).

False feedback can be beneficial to learning a novel motor task. Participants in Ávila, Chiviacowsky, Wulf, and Lewthwaite's (2012) study threw beanbags at a circular target using their non-dominant hand while wearing opaque goggles. Participants who were told they were performing better than they actually did showed higher accuracy during retention. Improvement in performance during acquisition was not significantly different from participants who did not receive false feedback. Ávila et al. (2012) suggested the improved performance in participants who received positive false feedback was due to an increase in motivation and perceived competence. This finding provided support that the belief of ability in one's performance can impact the acquisition of a novel skill.

A proposed mechanism to explain the positive effects of false positive feedback on learning was enhanced expectancy. Enhanced expectancy can be described as improving a learner's self-predicted level of performance through various methods, including social-comparative feedback (comparing one's performance to others; discussed in more detail in the introduction to Experiment 1), video recordings of the learner's best performance, and discussions of the learner's actual performance accomplishments (McKay, Lewthwaite, & Wulf, 2012). To demonstrate, McKay et al. (2012) used false reports of participants' abilities to perform under pressure to influence their performance. Participants first completed 20 baseball throws, then were asked to complete two questionnaires which measured their sense of ability and autonomy. Participants in the enhanced expectancy group were falsely informed that the questionnaires revealed they would perform well under pressure, and while those in the control group were given the same false reason for completing the questionnaire, their individual results weren't provided. All participants then completed another set of 20 throws, this time under pressure introduced by a prize to be won if the participant and a randomly selected partner both improved by 15% (they were informed their partner had already completed the requirement). In other words, the participant's performance in this second set of trials would decide whether or not the two of them would receive the prize. McKay et al. (2012) found accuracy scores in the first block of throws (before manipulations were administered) to not be significantly different between the groups. However under the pressure situation, the enhanced expectancy group showed significant improvement after being told they would perform well under pressure. Thus, McKay et al. (2012) have shown that enhancing one's belief in a generic ability (e.g. performing well under pressure) can have positive effects on specific motor tasks (e.g. throwing a baseball).

1.4 The Present Thesis

Witt's series of studies (Witt & Dorsch, 2009; Witt et al., 2008; Witt & Proffitt, 2005) have shown that the better the perceiver's performance, the more favourable the environment appeared, relative to the present task (e.g. larger targets for aiming tasks, shorter walls for climbing tasks). Witt et al. (2014) then extended their findings by showing that even if the perceiver was just observing a task, their own abilities still influenced their perception, rather than the observed individual's abilities. Foerster et al. (2015) sought to tease apart which aspect of performance contributed to the action specific effect, and found perception to be independent of variability in performance. Finally, recent studies have found that factors other than performance (e.g. mood, positive contagion) can also influence perception (Riener et al., 2011; Lee et al., 2011). Proposed mechanisms for the occurrence of the action specific effect were response biases (that participants were complying with what they think the hypothesis was), memory effects (that performance actually influenced memory of target size instead of perceived target size), and effects of visual attention (that focusing on a target accentuates its properties).

False feedback studies have shown that beliefs of successful or unsuccessful performances can be internalized (e.g. increased feelings of motivation and competence). Thus, levels of self-efficacy (self-reported ratings of confidence, motivation, and task difficulty) will be measured in this thesis to provide insight into whether or not our false feedback manipulations were internalized. Whether illusions of successful or unsuccessful performances (regardless of true performance) could still influence perception has not yet been studied (at the time of writing). Thus, the aim of this thesis is to replicate Witt et al.'s (2008) study, and to further determine whether feedback accurately reflecting true performance is a requirement for the perceptual bias effect to occur.

Specifically, Experiment 1 attempts to use false social comparative feedback independent of true performance (while still providing true trial-by-trial feedback) to influence target size perception. Because false positive feedback has been shown to increase feelings of self-efficacy and competence, which in turn enhances expectancies of ability and success, it is hypothesized that participants in the false positive feedback group (told they are better than other participants) would perceive the target as larger than participants in the false negative feedback group (told they are worse than other participants). The direction of target bias was predicted as such because past studies on the action specific effect have shown that when performing well, target objects appear more favourable. Thus in the case of this study, the target is predicted to appear larger (e.g. easier to aim for).

Participants in Experiment 2 only have access to false trial-by-trial feedback (independent of participants' actual performance), to determine if beliefs of individual success (or failure) can influence perception of target object sizes. It is hypothesized that participants who were led to believe they are performing better than they actually are (false positive feedback) would perceive the target size as larger than those who are led to believe they are performing worse (false negative feedback). If the hypothesis is supported, possible mechanisms could be response bias (if and when participants detect that the visual feedback didn't match their motor feedback) and enhanced expectancy (if they don't detect the manipulation).

A pilot study was previously conducted using Experiment 2's protocol to determine if manipulating participants' feedback to induce feelings of success (or failure) would still elicit the perceptual bias effect. The results did not support the hypothesis that receiving false positive feedback will lead to an overestimation of the target (i.e. golf hole) size, and receiving false negative feedback will lead to an underestimation. In other words, true action and perception appear to not be fully dissociated. These null results suggest either that true action and perception cannot be fully dissociated (and as such, the false feedback was not effective), some degree of true feedback may be required for false feedback to be believable, or that the limitations in the protocol may have interfered with the perceptual bias effect. Before it is concluded that true action cannot be fully dissociated from perception (or that some degree of true feedback may be required), the limitations in the pilot study were addressed (discussed as appropriate within Section 2.1.3) and the experiment was run again (Experiments 2 and 3). Feelings of success were induced in a different way in Experiment 1. Participants viewed their true feedback (thereby avoiding limitations raised during the pilot study), but were compared to the falsified feedback of other participants.

2.0 EXPERIMENT 1: The Influence of False Social Comparative Feedback

While performance-based feedback informs the learner about their own performance, social comparative feedback compares one's performance against the average performance of other individuals (Johnson, Turban, Pieper, & Ng, 1996). If an individual believed they are doing better than others, then they may experience an increase in self-efficacy, motivation, positive self-reactions (Lewthwaite & Wulf, 2010). False social comparative feedback, like false performance-based feedback, can also influence motor acquisition.

Ávila, Chiviacowsky, Wulf, and Lewthwaite (2012) found an increase in performance, task enjoyment, self-efficacy, movement automaticity, and a decrease in concern about ability and nervousness in children who were provided with false positive social comparative feedback. Participants threw beanbags at a circular target using their non-dominant hand while wearing opaque goggles. They received true feedback about their accuracy after every trial, but after every block of 6 trials, those in the positive feedback group were told that they were performing better than the children who did the same experiment at another school. Those in the control group only received true feedback after every trial. While accuracy in both groups improved as acquisition trials progressed, those in the positive feedback group had higher accuracy during retention. Ávila et al. (2012) suggested the enhancing effects of positive social comparative feedback on motor learning was due to an increase in motivation and perceived competence.

The positive contribution of false social comparative feedback occurs for adults as well. As discussed previously, the task Lewthwaite and Wulf (2010) had participants complete was to stand on a balancing apparatus that can sway side to side. Participants receiving false positive social comparative feedback acquired the skill significantly better than the false negative social comparative feedback group, as shown through greater increases in performance during acquisition, and better performance during retention. Similarly, Pascua et al. (2015) found that an increase of self-efficacy (partially due to enhanced expectancy induced by false social comparative feedback) improved performance in retention and transfer phases. Participants aimed for a target using an overarm throw with their non-dominant arm. The acquisition phase consisted of six blocks, and in between each block, those in the enhanced expectancy group were told that they were performing 20% better than average (i.e. positive social comparative feedback). After acquisition, they filled out a questionnaire to assess self-efficacy and positive and negative affect. Those that received false positive social comparative feedback had a higher degree of accuracy in retention and transfer compared to the control group. Further, they had higher ratings of self-efficacy and positive affect. These positive effects can be due to the self-fulfilling prophecy phenomenon (Wulf, Shea, & Lewthwaite, 2010). Merton (1948) describes the phenomenon as false information that brings about new behaviour which transforms the false information into true information. In the case of false feedback during motor experiments, a participant performing at average levels being falsely informed that they were performing above average may experience a change in behaviour (e.g. higher levels of self-efficacy which may lead to higher levels of motivation and effort (Bandura, 1982)) which in turn may actually make the false claim of their above average performance true. Conversely, if a participant was told they were performing below average, their changes in behaviour (e.g. lower levels of self-efficacy, increased anxiety) may make the false claim of their below average performance true. Thus, false social comparative feedback can have a significant effect on a learner's acquisition of a novel motor skill.

The purposes of Experiment 1 of this thesis were to replicate Witt et al.'s (2008) results using a putting task, and to investigate whether falsified social comparative feedback could influence the perception of target size. In other words, whether it is possible to elicit similar perceptual biases in the absence of actual motor success (e.g. is simply being told you are successful relative to a group mean as good as actually performing well?). Since positive social comparative feedback suggests an individual is performing well, and because Witt's series of studies suggested that performing well was related to larger target size perceptions (Witt & Dorsch, 2009; Witt et al., 2008; Witt & Proffitt, 2005), it was hypothesized that those in the false positive social comparative feedback group will perceive the target to be significantly larger than the false negative social comparative feedback group. This was predicted because mechanisms such as the self-fulfilling prophecy and enhanced expectancy suggest that being told one is performing better than others can increase motivation and feelings of self-efficacy. The null hypothesis was that there was no difference in perceived target size between false positive and negative social comparative feedback. The support of these hypotheses is important at a theoretical level. Specifically, should the predicted results occur, it would suggest that any perceptual biasing effects arise at a level of cognition (i.e. more top down) rather that at lower motor level - wherein such biases are situated within a larger internal representation of acquired ability (i.e., more bottom up).

2.1 Methods

2.1.1 Participants

Twenty-two (11 male) right-handed participants aged 18 – 30 years old (*M* = 21.5, *SD* = 3.8) were recruited for this experiment. Participants could not have engaged in golfing or mini-putting more than 3 times in the past year, and were naive to the purpose of the study. They were recruited through the use of posters displayed across the campus of McMaster University (see Appendix A1). They all received monetary compensation of $5 at the end of the experiment. All portions of this study were approved by the McMaster Research Ethics Board.

2.1.2 Apparatus and Materials

Putting Task

Please refer to Figure 1 for a diagram of the experimental setup. The putting green was 648 cm x 134 cm, and black bumpers (11 cm high) surrounded three sides at the end of the putting green where the circular target was located. The target was 10.8 cm in diameter, and was made of black felt. Concentric rings were drawn with white chalk around the target, and increased by 5.0 cm in radius per ring, to a maximum radius of 70.0 cm. Participants used a standard golf ball (Callaway Golf, Grade C, 4.0 cm in diameter), and putted with a T-Line IV by PGA golf putter (89.0 cm in length). To ensure participants could not observe the experimenter applying deceptive manipulations, participants wore liquid crystal goggles (Translucent Technologies, Toronto, Ontario), and a headset (Sony Over-Ear Noise Cancelling Headphones (MDRNC8B)) that played white noise through a portable music player (iPod Shuffle, Apple Inc., Cupertino, California). The volume level was adjusted for each participant such that the experimenters' voices were inaudible.

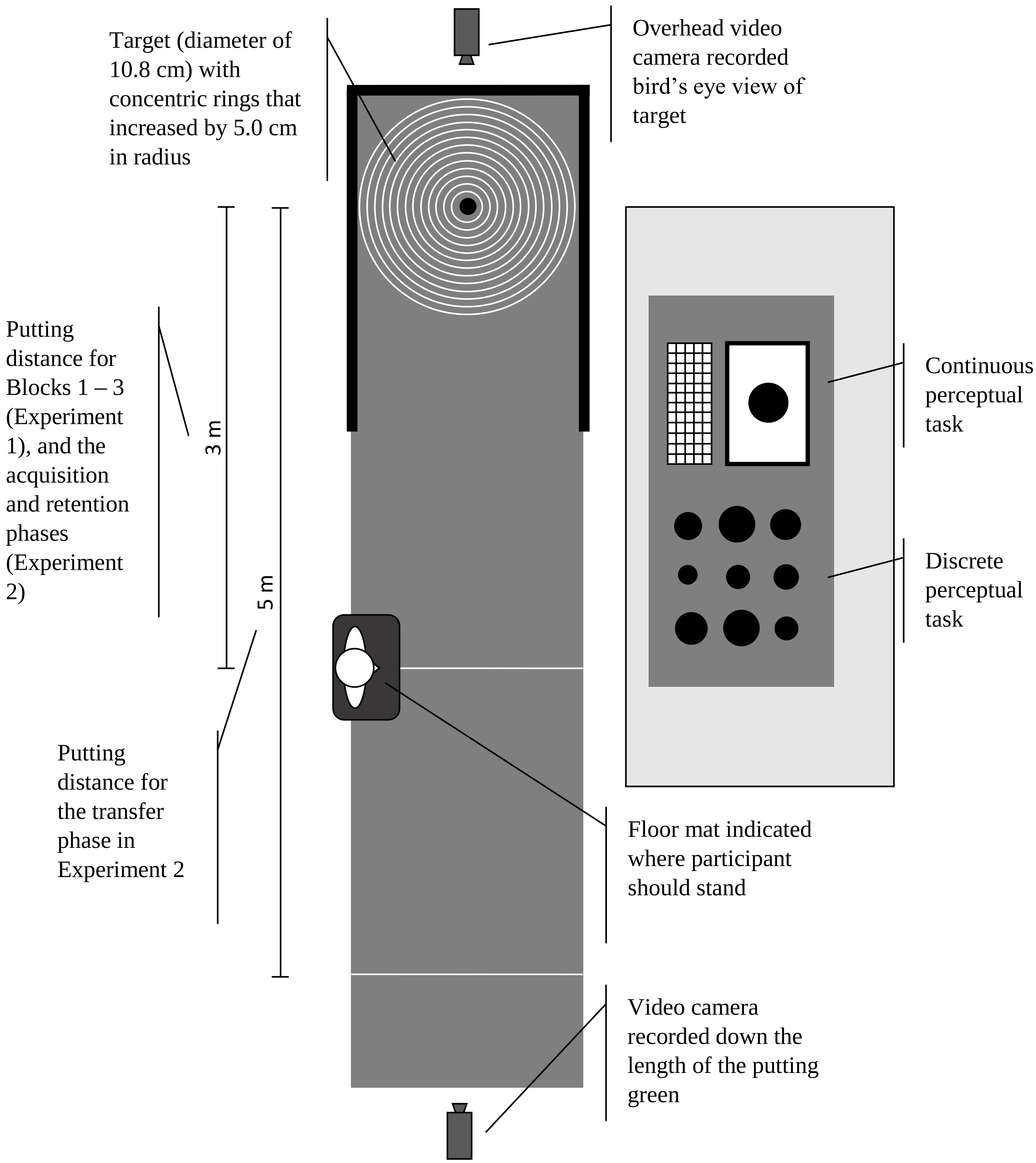

Figure 1. **Diagram of the setup. Participants putted towards the black target, then completed perceptual tasks located at the table to the right of the setup.**

Two video cameras (GoPro HERO3+ Silver Edition and Canon PowerShot A460) were used to record the experiment. The first camera was mounted on the ceiling to provide a bird's eye view of the target. The second camera stood on a tripod to record down the length of the putting green.

Perceptual Tasks

Two perceptual tasks were completed by each participant. Both perceptual tasks were set up on a table on top of a length of putting green to best match the surroundings of the actual target.

The first perceptual task was a "continuous" size matching task, completed on the computer. A computer monitor (Samsung SyncMaster 910T 19-inch LCD) was laid horizontally on the table and displayed a black circle on a white background. The same custom MATLAB (MathWorks, Natick, Massachusetts) program that was used in the pilot study was used again in this thesis. The up and down arrow keys on the keyboard were used by the participant to increase or decrease the size of the circle. This task was introduced in the pilot study because it provided a more dynamic and precise measure of target size estimations. Participants could adjust the circle by the pixel, instead of choosing from a limited set of predetermined circle diameters.

The second was a "discrete" perceptual task, completed using nine black circles cut out of poster board. This perceptual task reflected the one that Witt et al. (2008) used. For this thesis, nine black circles were cut out of poster board, with diameters that ranged from 8.2 cm to 12.2 cm (see Table 1). One matched the exact target size (10.8 cm). Unlike Witt et al. (2008), who arranged the circles from smallest to largest (from top left corner to bottom right corner of the poster board), our circles were shuffled then arranged randomly in a 3 x 3 layout every time the participant was to make an estimate. This task was included in addition to the continuous task to have a more direct comparison with the original Witt et al. (2008) data.

Table 1

Circle Diameters (cm) for the Discrete Perceptual Task

8.2	
8.7	
9.2	
9.7	
10.2	
10.8	Actual golf hole size
11.2	
11.7	
12.2	

The pilot study only used the continuous perceptual task because it offered a better resolution of target size estimations. However, because the pilot study found null results, the discrete perceptual task was included in this thesis to replicate Witt et al.'s (2008) study. If their findings can be replicated, that would suggest that the introduction of the occlusion goggles and the white noise did not interfere with Witt et al.'s (2008) original task.

Falsified Feedback

Histograms were used to provide false social comparative feedback. This will be discussed in further detail in Section 2.1.3, Block 2.

2.1.3 Procedure

Both the experimenters and participants removed their shoes prior to the experiment, to minimize the risk of participants hearing the movements of the experimenters. Participants were informed of the general methods of the study and signed a consent form (see Appendix B1) prior to participation. Participants were provided with a fictitious experimental objective which outlined that the current experiment investigated the effects of sensory deprivation on the acquisition of a novel motor skill. Next participants completed a demographic questionnaire (Appendix C, questions 1 – 4), and completed the first part of the self-efficacy questionnaire (Appendix C, questions 5 - 6).

Participants were asked to putt the golf ball to the target from the putting line located 3 metres away from the centre of the target. If the ball hit the bumpers or fell short of the concentric circles, the trial was considered invalid. Participants completed 2 practice trials without the occlusion goggles or the white noise, and immediately following, 2 practice trials with both the goggles and white noise.

Block 1

Putting Task

One experimenter operated the goggles and the white noise (please refer to Figure 2 for a visual depiction of the timing and use). When the participant indicated that they were ready to begin the trial, the experimenter initiated the white noise. As soon as the putter made contact with the golf ball, the goggles became opaque to occlude the participant’s vision, and remained that way for the next 20 seconds. During this time, participants were instructed to stand still with their heads down. This was when the other experimenter secretly recorded the participant's performance (quadrant and radial error). The white noise terminated after 10 seconds instead of in conjunction with the goggles because while 20 seconds were required to record the score, listening to white noise for the entire duration was determined through pilot testing to be uncomfortable. Although the goggles and the white noise did not have a direct purpose in this experiment, it was a very important component in Experiment 2, so they were adopted to maintain consistency between experiments.

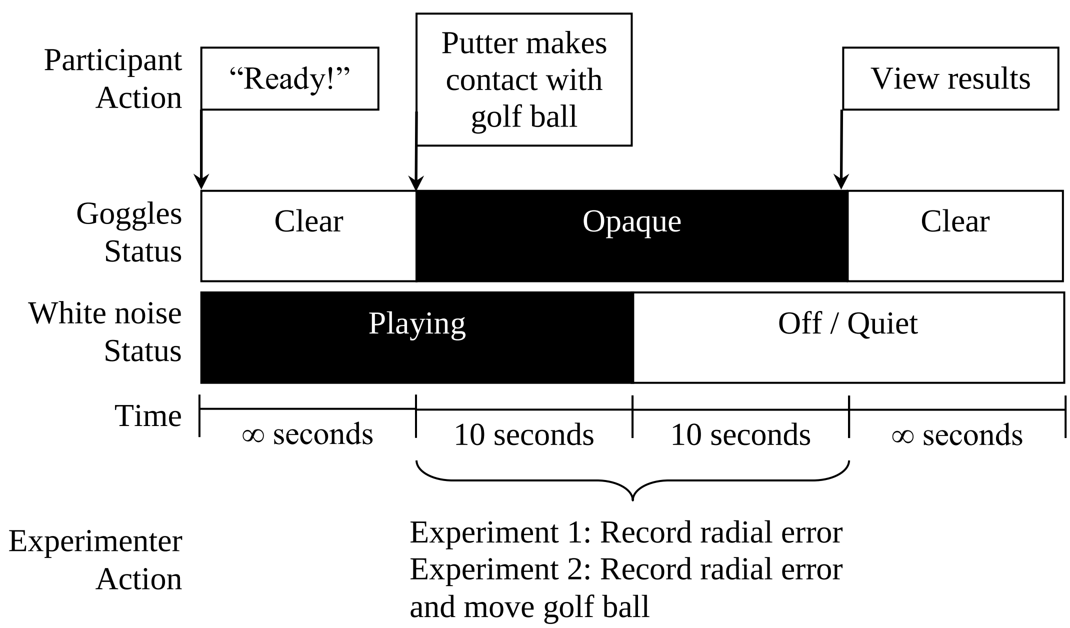

Figure 2. **Visual depiction of the timing and use of the white noise and goggles.**

One limitation to the pilot study was that because the experimenter retrieved the golf ball for the participants, they weren't able to view the target directly. Thus in Experiment 1, if the trial was valid (defined as putts landing within the white circles – in other words, a radial error less than 70 cm), the participant walked up the green and retrieved their golf ball with their hand. This increased the amount of interaction and passive attention participants had towards the target, and ensured that visual angle was not a factor that altered their perception of the target. If the shot was an error (defined as the ball hitting the bumpers or landing anywhere outside the largest white circle – in other words, a radial error greater than 70 cm), the experimenter picked up the ball and returned it to the putting line before the 20 seconds had passed. This ensured that all participants had the same number of opportunities to both view their results and the target directly.

Perceptual Task

After participants completed 16 valid trials, the target and concentric circles were covered with a large sheet of cloth, and participants completed the perceptual tasks where they were asked to estimate the size of the target. First, they completed the continuous perceptual task on the computer. In the pilot study, participants did two counterbalanced perceptual trials, where they estimated the size of the target by changing a black circle on the monitor from small to large, and from large to small. It was suspected that any effects the pilot study may have found was cancelled out by the opposing directions of undershoot and overshoot biases associated with starting small and large respectively. Thus in the present study, the direction of circle manipulation from small to large or large to small was counterbalanced between participants as opposed to within participants. This way, if the opposing directions experienced within the same participant did in fact cancel out any effects in the pilot study, having each participant manipulate the circle in the same direction for each instance of target size estimation will alleviate this possibility.

Next, they completed the discrete perceptual task, where they pointed to the black circle most closely matching the size of the target. Before this task, the circles were shuffled and placed randomly in a 3 x 3 arrangement. The discrete perceptual task was included in an attempt to replicate Witt et al.'s (2008) findings. Following the perceptual tasks, participants filled out the remainder of the self-efficacy questionnaire (Appendix C, questions 7 - 9).

Block 2

Immediately following Block 1 participants completed another 4 valid trials without the goggles and the headset. However, to remain as consistent as possible with Block 1, participants were asked to look away when their putter came into contact with the golf ball, and to remain standing quietly until 20 seconds had passed (i.e. the same amount of time that the goggles had been occluded in Block 1). The perceptual tasks were then repeated.

To simulate the calculation of their scores, the participants completed a distractor task (tangrams) during a 2 minute break wherein the experimenter pretended to enter their scores into Microsoft Excel 2013.

Immediately after the break, participants were provided feedback through one of two simple histograms (Figures 3 A and B). There were two experimental conditions: false positive and false negative feedback groups. Those in the false positive feedback group viewed a graph showing that they had a score 20% higher than average, and those in the false negative feedback group saw that they were 20% lower than average –

regardless of their actual performance on the putting task. The percentage of differences from the falsified average were chosen because Lewthwaite and Wulf (2010) used those differences in their study. Further, the differences could not be so large as to make the feedback unrealistic, and not be so small that the effects of the false feedback might be weakened.

A B

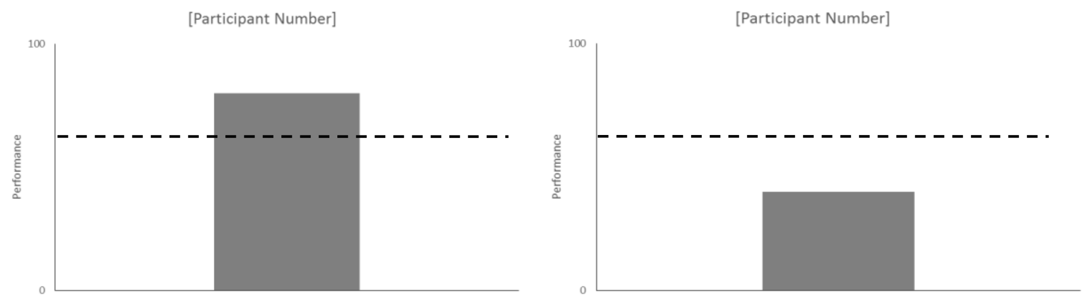

Figure 3. **Simple histograms used to provide false social comparative feedback. False positive feedback participants (A) were informed to be performing 20% better than the falsified average (dotted line), and false negative feedback participants (B) were performing 20% worse.**

Block 3

Participants completed a final set of 8 valid trials without the goggles and headset, followed by the two perceptual tasks, and the self-efficacy questionnaire. Figure 4 illustrates how the entire experiment progressed.

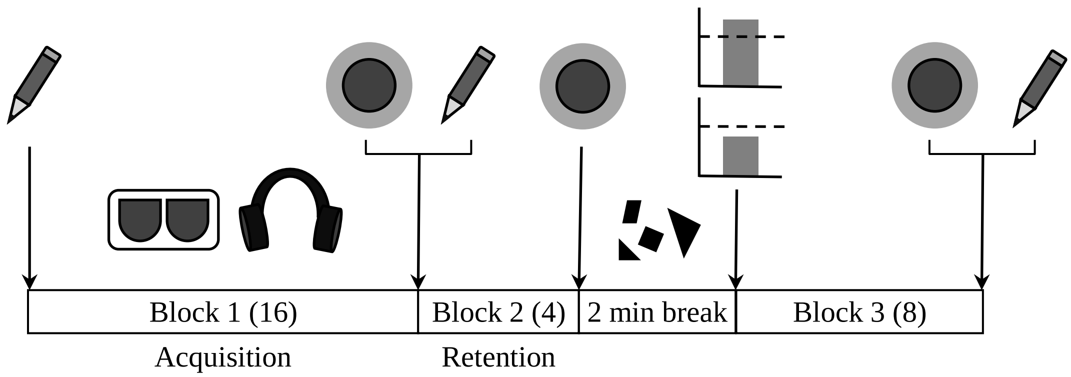

Figure 4. **Visual depiction of the progression of Experiment 1. Pencils represented completion of the self-efficacy questionnaire, circles represented completion of the perceptual tasks, and the histograms represented the administration of false social comparative feedback. The items above a block (goggles, headset, and tangrams) represented the usage of those items during that block. Block 1 is reflective of Experiment 2's Acquisition Phase, and Block 2 is reflective of Experiment 2's Retention Phase.**

They received monetary compensation of $5 at the end of the experiment.

Conclusion of Study

Once all three experiments were completed, Debriefing Letters (Appendix D1 for Experiment 1, Appendix D2 for Experiment 2) and Post Debrief Implied Consent forms (Appendix B3) were emailed to all participants.

2.1.4 Data Analysis

The primary dependent variable was the target size perceptions, defined as the diameter of the golf hole circles as drawn for the continuous perceptual task (from here on referred to as "computer perception"), and the diameter of the golf hole circles as chosen for the discrete perceptual task (from here on referred to as "paper perception"). The secondary dependent variables were related to performance: average radial error, total number of trials, the percentage of trials that were invalid (from here on referred to as “errors”), and previous trial effects. The last set of dependent variables were measures of self-efficacy (confidence, motivation, and difficulty). The independent variables were feedback group (false positive or negative social comparative feedback) and time (Block 1, 2, or 3).

In addition, it has been demonstrated that performance and the information available from a previous trial can influence the performance on the following trial (Cheng, Luis, & Tremblay, 2008). For instance, if on the previous trial the participant had overshot, they can use this feedback during the next trial. They may shoot more gently to correct for the error in the previous trial. Thus, information from a previous trial analysis can provide clues to the motor planning participants are undergoing. In order to analyze the influence of a previous trial’s radial error on the current trial’s radial error, that previous trial must have been valid. This was because invalid trials did not have a recorded radial error (e.g. if the ball hit the bumper, the radial error could not be extrapolated accurately). Due to the number of errors per participant and how they were interleaved between the valid trials, analysis could only be done on the percentage of total trials that were overshoots followed by overshoots (OO), overshoots followed by undershoots (OU), undershoots followed by overshoots (UO), and undershoots followed by undershoots (UU).

Because the dependent variables had a significant skew (> 1 or < -1), the data were not normally distributed and thus non-parametric analyses were used. Outliers were identified using the Interquartile Range (IQR) method on the main perception variables (computer and paper perception). Participants with responses greater than or less than 1.5 times the interquartile range were omitted from data analysis. To satisfy the requirement of nonparametric analyses, Spearman rank-order correlations were run. The Mann-Whitney U test was used to detect differences between two independent groups, and the Wilcoxon signed rank test detected differences within two groups. Kruskal-Wallis tests were used when testing for significant differences between more than two groups. Significance was set at $\alpha < .05$.

To replicate Witt et al.'s (2008, Experiment 1) study, a one-tailed Spearman rank-order correlation was run between radial error and the perceptual tasks. One-tailed tests are run when experimenters are predicting the results to differ from the mean in a specific direction (hence, one-tailed tests are also known as directional tests) (Howell, 2008). Although past studies have suggested a particular direction (better performance is related to perceiving the target object as larger (Memmert et al., 2009; Witt & Dorsch, 2009; Witt et al., 2014)), the present thesis will use two-tailed tests after initially attempting to replicate Witt et al.'s (2008, Experiment 1) study with a one-tailed test. This was because two-tailed tests do not require a prediction of which direction the results will go. Howell (2008) says that in the case that the null hypothesis cannot be rejected, a one-tailed test cannot offer insight into whether or not the data is significantly different in the direction opposite to the hypothesis. Because a two-tailed test can, failing to reject a null hypothesis means one can be fairly confident that the data are not significant in either direction – thus offering a more robust analysis. Further, Witt et al.'s (2008) hypothesis was only in one direction, which was that the better the performance, the bigger the target size estimation. The present thesis' hypothesis had two directions, which was that the false belief of one's success led to bigger target size estimations, and the false belief of one's failure led to smaller target size estimations. Hence, two-tailed tests were used after replicating Witt et al.'s (2008) study with a one-tailed test.

2.2 Results

2.2.1 Skew and Outliers

Significant skew was identified on the following primary dependent variables: post Block 1 paper perception (skewness of -1.15, *SE* = 0.16), post Block 2 paper perception (skewness of -1.52, *SE* = 0.23), and post Block 3 paper perception (skewness of -1.31, *SE* = 0.19). Because the data in the primary dependent variables were skewed, non-parametric data analyses were used.

The IQR method detected two outliers, one in each feedback group. The remaining 20 participants (10 male) were aged 18 – 30 years old (*M* = 21.8, *SD* = 3.9).

2.2.2 Block 1: Replication of Witt et al.'s (2008) Study

Because Block 1 occurred before any falsified feedback was given, it was used to replicate Witt et al.'s (2008, Experiment 1) study (and later, acted as this thesis' control group in Experiment 2). Witt et al. (2008) found a significant negative correlation using a one-tailed Spearman rank-order test between course scores (performance) and paper perception, $r_s(46) = -.30$, $p = .02$. This negative correlation was not found between Block 1's radial error (performance) (*Mdn* = 39.8 cm) and paper perception (*Mdn* = 11.7 cm),

$r_s(18) = -.03$, $p > .05$. This may have been because Witt et al.'s (2008) participants engaged in golf in a naturalistic setting. Their participants' main goal while they golfed was to land the ball in the hole in as few strokes as possible. In the present thesis, participants had the secondary goal of not committing an invalid putt. Thus, the divide in attention may have decreased the effect (Cañal-Bruland et al., 2011).

However, the higher resolution that the computer perceptual task provided may have been able to detect the weakened effect. A significant negative correlation was revealed between Block 1 radial error (*Mdn* = 39.8 cm) and Block 1 computer perception (*Mdn* = 11.8 cm), $r_s(18) = -.39$, one-tailed, $p < .05$. Regardless of feedback group, the poorer the performance (larger radial error), the smaller the perceived target size (Figure 5.1).

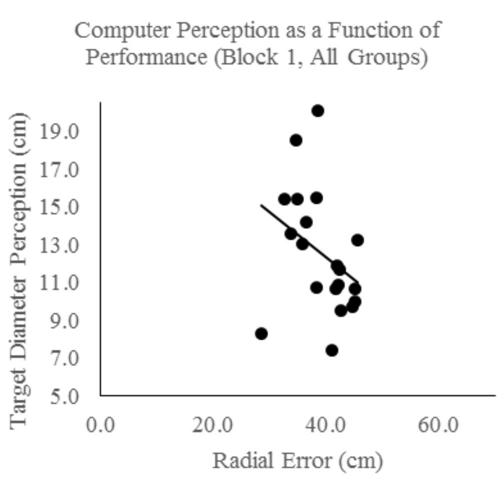

Figure 5.1. **Computer perception (*Mdn* = 11.8 cm) was correlated with Block 1 radial error (*Mdn* = 39.8 cm), $r_s(18) = -.39$, one-tailed, $p < .05$. The solid line is the line of best fit.**

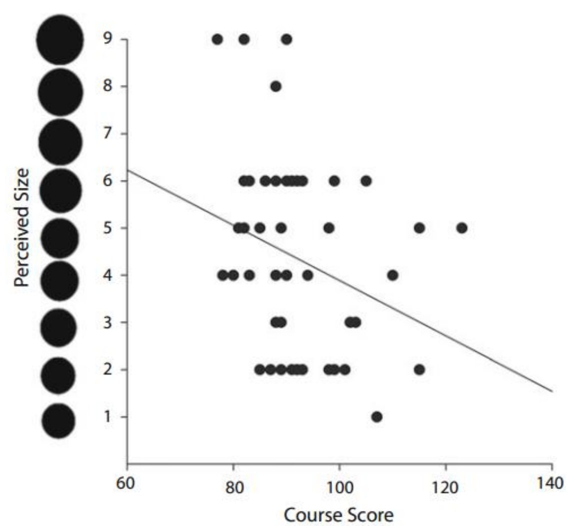

Figure 5.2. **Paper perception in Witt et al.'s (2008, Experiment 1) study was correlated to golf scores, $r_s(46) = -.30$, one-tailed, $p = .02$, as shown by the solid line. The circles on the y-axis represented the 9 circles from which participants chose.**

This replicated Witt et al.'s (2008) findings (Figure 5.2) because the Spearman's Rho values were similar, and the direction of the correlation (negative) was the same. Also, Block 1's computer perceptual task (*Mdn* = 11.8 cm) was significantly positively correlated to Block 1's paper perceptual task (*Mdn* = 11.7 cm), $r_s(18) = .68$, one-tailed, $p < .01$. This suggested that while the effect found in computer perception reflected paper perception, because computer perception was more robust (due to a higher resolution and fewer constraints in possible size estimations), it was significantly correlated to performance even when paper perception was not. Thus, because the computer perception task was able to replicate Witt et al.'s (2008) findings, and was also correlated to the paper perception task, it was the only perceptual task used in data analysis from this point forward.

Participants in Block 1 were assessed as one group because no feedback manipulations have been administered yet. A Wilcoxon signed-rank test was run on self-reported ratings of confidence and motivation pre-Block 1 and post-Block 1. No significant differences were found (Figures 6.1). Task difficulty rating had a median of 65% (Figure 6.2). Together, they suggested that the task itself was not too difficult. This was important because the task should be reasonably challenging (such that false negative feedback was believable), but also be possible to learn (such that false positive feedback was also believable). This was shown through confidence and motivation ratings that did not significantly change after having completed the task, and through a difficulty rating that suggested the task was slightly more difficult than neutral.

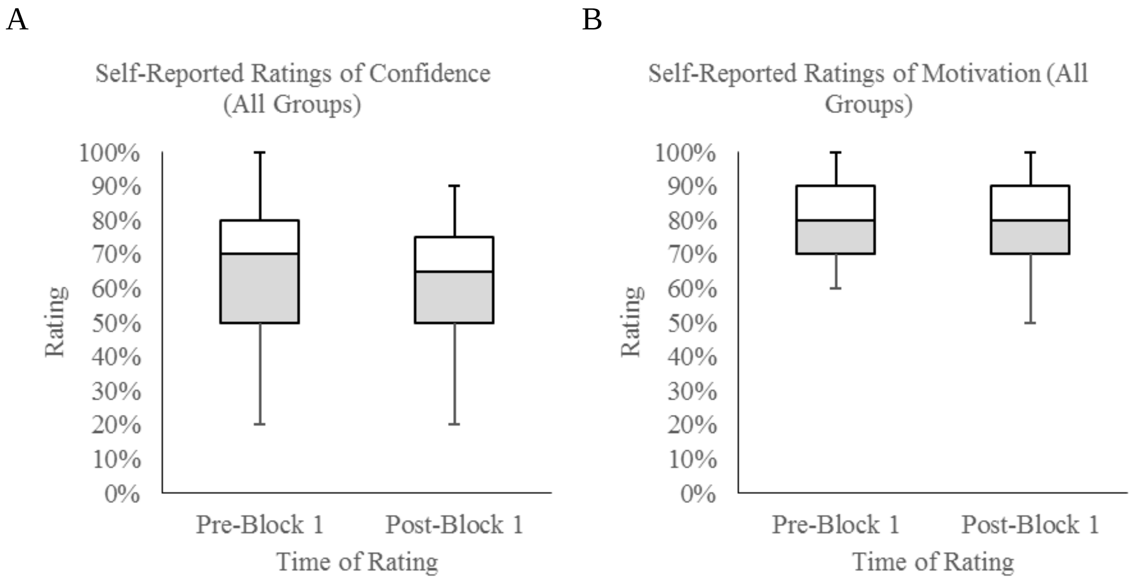

Figure 6.1. **Confidence (A) and motivation (B) ratings collapsed across group, before experimental manipulations were administered.**

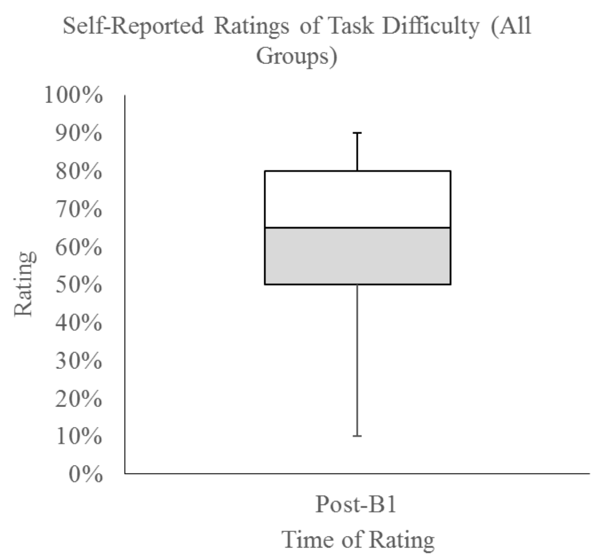

Figure 6.2. **Task difficulty ratings collapsed across group, before experimental manipulations were administered.**

Feedback from the previous trial has been shown to influence the motor planning and execution of the following trial (Burkitt, Staite, Yeung, Elliott, & Lyons, 2015;

Cheng et al., 2008). Because participants so far have not received differential treatment, the previous trial type analyses were run to determine the baseline influence of previous trials on current trials (e.g. development of error correction). Figure 7 illustrates the results of the previous trial analysis.

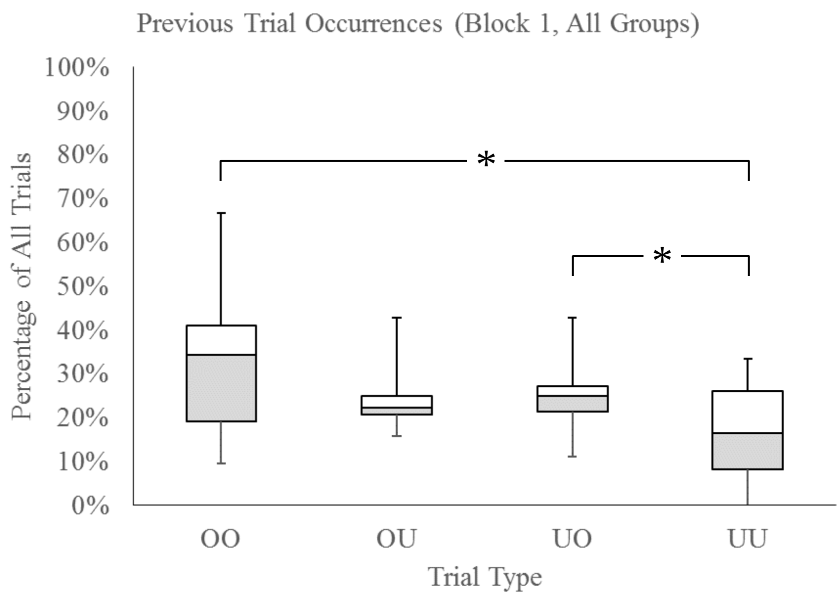

Figure 7. **Percentage of all trials in Block 1 that were OO, OU, UO, or UU.**

A 4 previous trial type (OO, OU, UO, UU) x 1 time (Block 1) Kruskal-Wallis found more instances of OO (*Mdn* = 34%) than UU (*Mdn* = 16%), $\chi^2(3) = 14.7$, $p < .05$. Since participants were more likely to repeat an overshoot error than an undershoot error, this suggested that it may have been more difficult to correct for overshoots than undershoots. This may have been due to the difficulties introduced using the occlusion goggles and headset. Following invalid trials, participants were not provided visual feedback – they were only informed whether the putt was too long or too short. Thus, it was difficult for participants to gauge the relationship between the strength of their swing, and the resulting distance travelled by the golf ball. For undershoots, the possible distance travelled by the golf ball is restricted to the distance between the participant and the largest white circle. For overshoots, the possible distance travelled by the golf ball is impossible to estimate because its path is interrupted by the bumper. Thus, it was suspected that participants were better able to create a mental relationship between gentle swings and undershoots than strong swings and overshoots. UO (*Mdn* = 25%) also occurred significantly more than UU, $\chi^2(3) = 14.7$, two-tailed, $p < .05$. This finding agrees with the previous speculation that undershoots were easier to correct. The greater frequency of UO trials suggested that participants were more likely to successfully correct the undershot and thus less likely to repeat it (i.e. UU trials). Thus, when possible, participants showed that they used feedback from previous trials to execute their current trial. This was consistent with past research that showed previous trials influenced current trials (Burkitt et al., 2015; Cheng et al., 2008).

2.2.3 Block 2: Retention Phase, Removal of Goggles and White Noise

Block 2 differed from Block 1 in that participants completed the putting task without the goggles and the white noise (please see Figure 4), and the Block ended after four valid trials.

There were no significant correlations between performance variables (radial error and errors) and computer perception. This may have been due to a combination of a change in the procedure, and insufficient time to adapt. In Block 1, participants had no control over when they had vision and hearing due to the use of the goggles and headset.

In Block 2, although participants didn't have to use the goggles and headset anymore, they were asked to refrain from looking at their shot after their putter came into contact with the ball (in an attempt to remain consistent with Block 1). In other words, they had to consciously control what they could see. The change in the procedure was significant because participants had to divide their attention between aiming and putting to the target circle, and timing when they should stop looking at the ball. Because the median amount of trials it took to complete four valid putts was five, there may have been insufficient time to adapt to the change in procedure, and thus any perceptual bias effects may have been weakened.

No self-efficacy questionnaires were administered in Block 2. They were administered before and after Block 1 to investigate possible psychological changes, and whether the task was unreasonably challenging. They were administered after Block 3 to investigate any effects on self-efficacy after false social comparative feedback was shown (Ávila et al. (2012) and Lewthwaite and Wulf (2010) found that self-efficacy can be influenced by false social comparative feedback). Because the task would have already been analyzed for how reasonable it was (using Block 1's ratings of self-efficacy), and because no false feedback had been used in Block 2, self-efficacy questionnaires were not administered.

There were also no significant differences in the previous trial analyses. This supported the earlier speculation that there was not enough time (i.e. trials) to adapt for changes in the procedure. Participants were potentially not using feedback from their previous trials because their attention was divided between aiming for the target circle and timing their gaze such that they aren't looking at the ball right after the putter comes into contact with it.

2.2.4 Block 3: After False Social Comparative Feedback

In the present study, false feedback manipulations were administered immediately before the commencement of Block 3. Participants again did not use the occlusion goggles and headset.

While there were no significant correlations between radial error and target size perceptions collapsed across feedback group, there was a significant negative correlation between the radial error of the last trial in Block 3 (i.e. the most recent trial) (*Mdn* = 37.0 cm) and computer perceptions (*Mdn* = 11.3 cm), $r_s(18) = -.54$, $p < .05$ (see Figure 8).

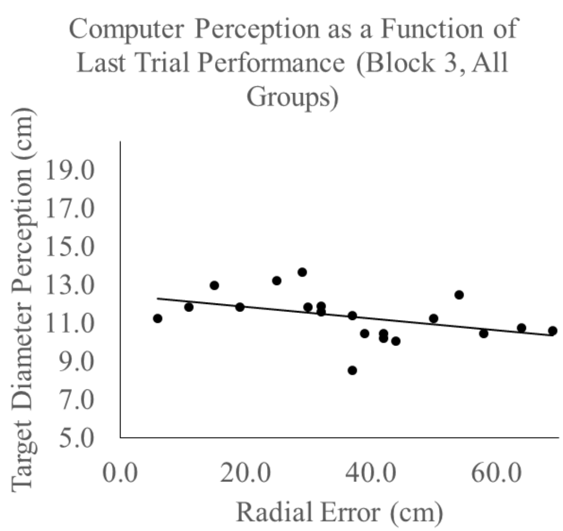

Figure 8. **Correlation between the radial error of the last trial in Block 3 and computer perception.**

When analyzed between groups, this correlation was only found in the positive feedback condition. Their radial error of the last trial in Block 3 (*Mdn* = 40.5 cm) was correlated with computer perception (*Mdn* = 10.9 cm), $r_s(8) = -.65$, $p < .05$ (see Figure 9).

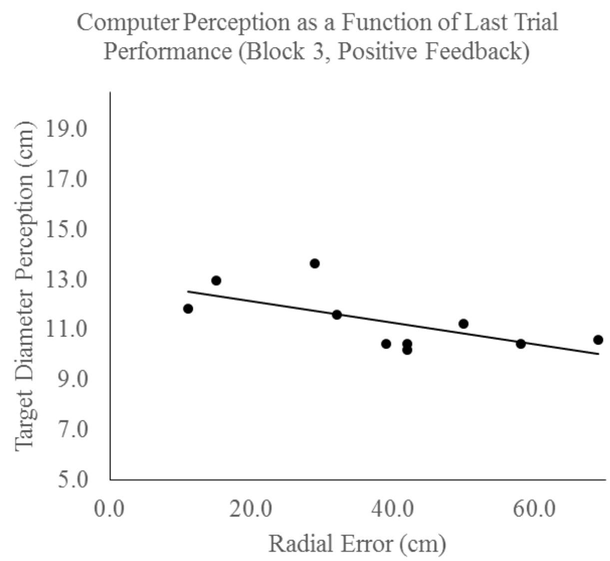

***Figure 9.* Computer perception correlated to last trial performance in the positive feedback group post-Block 3.**

Because these correlations were not significant in the negative feedback group, it appeared that after false social comparative feedback, the perception of those who were informed they were better than others may have been more significantly influenced by their most recent performance (rather than the average performance over a period of time). Cognitive fatigue may have made it difficult for both groups of participants to direct visual attention to the target while they concentrated on completing the putting task correctly. Positive feedback participants however, may have been more motivated (Ávila et al., 2012; Lewthwaite & Wulf, 2010) to complete their target size estimations accurately, and so they may have relied on their most recent experience (i.e. last trial) of the target.

Witt et al. (2008) found a difference in target size perception between their easy and hard experimental groups. Since the experimental manipulation was administered only before the start of Block 3 in the present study, target size estimations post-Block 3 were compared using a two-tailed Mann-Whitney U test. Although there were no significant differences in computer perception post-Block 3 between the positive (*Mdn* = 10.9 cm) and negative (*Mdn* = 11.6 cm) feedback groups, $Z = 0.49$, $p > .05$, $r = 0.1$ (see Figure 10), the positive feedback group trended towards a more accurate estimation. This may imply a shift in visual attention. False positive feedback participants may have become more motivated to accurately estimate the target size after being told they performed better than other participants. False negative feedback participants may have become less motivated to achieve the goals outlined for them (i.e. putt to the target as accurately as possible, estimate the target size as accurately as possible), and instead focused on finishing the experiment. Thus, they may have directed their visual attention towards the minimum requirements for a valid putt, the largest white circle. This may have introduced an overestimation bias (since the largest white circle has a much larger diameter than the black target circle). This was shown through a trend in target size overestimation for the false negative feedback group (see Figure 10).

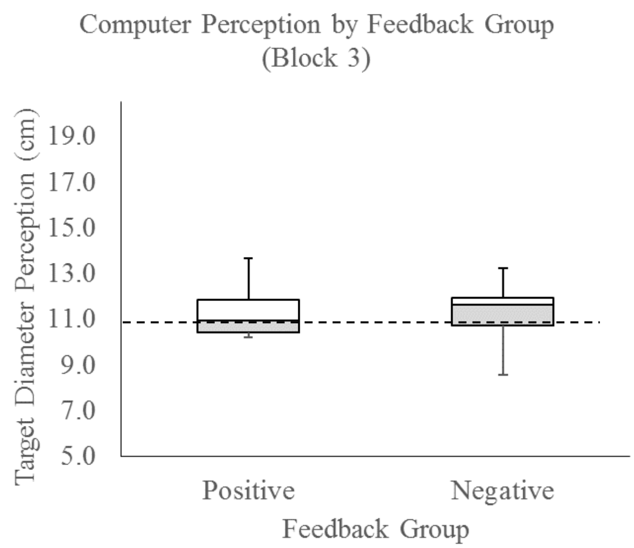

Figure 10. **Computer perception post-Block 3, by feedback group. The dashed line indicates the actual target size (10.8 cm).**

There were also significant negative correlations between radial error (*Mdn* = 38.9 cm) and both post-Block 3 ratings of confidence (*Mdn* = 70%), $r_s(18) = -.53$, $p < .05$, and motivation (*Mdn* = 80%), $r_s(18) = -.49$, $p < .05$, collapsed across groups. This correlation was not present in Blocks 1 and 2, which was before false social comparative feedback. This suggested that radial error had a stronger influence on confidence and motivation afterwards, in Block 3. This may have been because in the trials following the false feedback, participants may have interpreted their performance relative to the false feedback. That is, if their performance following the false feedback was consistent with the false feedback, it may have confirmed to them their performance relative to others (e.g. a false negative feedback participant may have seen that they were indeed worse and thus had lower confidence and motivation). If their performance following false feedback was instead inconsistent with the false feedback, it may have exaggerated their levels of self-efficacy (e.g. a false negative feedback participant who saw they were performing well may have experienced higher confidence because they have interpreted it as improvement). This significant correlation between radial error and post-Block 3 ratings of confidence was important because it suggested there was an internal change in participants after having received false social comparative feedback.

To analyze whether this internal change impacted their abilities to learn the novel motor task and whether it also impacted perception, participants' performance and perception was compared to their own performance and perception from before administration of the false feedback. The Wilcoxon Signed-Rank test found no significant change in radial error and target size perception within participants for both positive and negative feedback groups. However, positive feedback participants had significantly less errors in Block 3 (*Mdn* = 20%) than in Block 1(*Mdn* = 38%), $Z = -2.80$, $p < .01$ (see Figure 11).

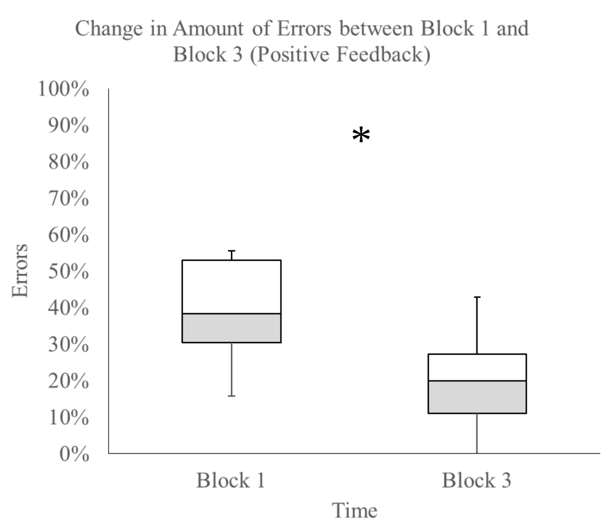

Figure 11. **Change in performance (as measured by the amount of errors) between Blocks 1 and 3 for positive feedback participants.**

Negative feedback participants on the other hand, did not show this decrease in errors. Thus, consistent with Ávila et al.'s (2012) findings, it appeared that positive feedback participants showed bigger improvements in performance in Block 3 than negative feedback participants, which implied better learning. It was suspected that this may have been due to a positive change in self-efficacy.

To investigate whether internal changes as a result of false social comparative feedback was a likely factor to better learning in positive feedback participants, Wilcoxon Signed-Rank tests were run on the ratings of confidence, motivation, and task difficulty between post-Block 1 and post-Block 3. There was only a significant difference in positive feedback participants' ratings of task difficulty (see Figure 12).

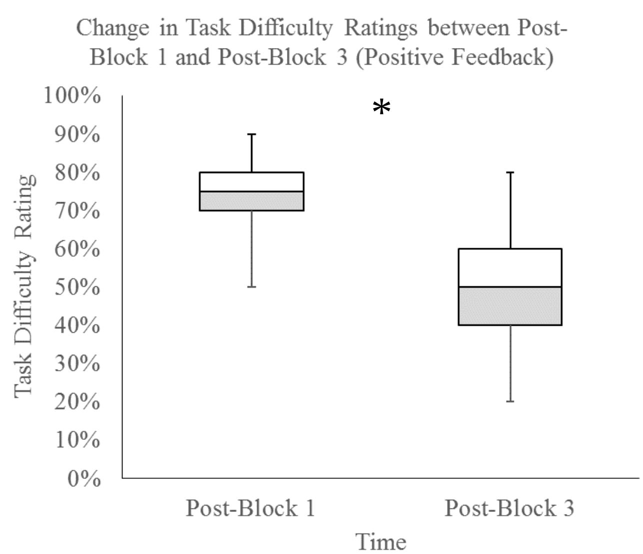

Figure 12. **Change in task difficulty ratings between post-Block 1 and post-Block 3 for positive feedback participants.**

Thus, while positive feedback participants felt the task was less difficult after receiving false social comparative feedback (*Mdn* = 50%) than before receiving it (*Mdn* =

75%), $Z = -2.39$, $p < .05$, negative feedback participants had no change in ratings of task difficulty. Since the task between participants was identical, just being told that one was performing better than others could make the task feel easier (because regardless of how they were performing, they were led to believe that others were performing worse than them). This could skew their perception of the task difficulty. Thus, this decrease in feelings of difficulty may have contributed to increased levels of task interest and engagement, which then allowed for a decrease in the amount of errors (Ávila et al., 2012).

There were no changes in the percentages of OO, OU, UO, or UU trials within feedback group, except for the percentage of OO trials in Block 1 (*Mdn* = 32%) versus in Block 3 (*Mdn* = 11%) for the negative feedback group, $Z = -2.26$, $p < .05$. It was speculated that perhaps after receiving negative social comparative feedback, participants became more conservative with their putts (hence the decrease in OO shots). The general lack of change in the percentages of OO, OU, UO, and UU trials suggested that by the end of Block 3, when participants were not using the goggles and the headset, they may have readjusted to levels of error correction similar to Block 1, when they were using them (recall that in Block 2, the absence of significant differences in previous trial types was speculated to be due to insufficient time to adapt to the absence of the goggles and headset while employing error correction strategies).

2.3 Discussion

Experiment 1 was intended to be an extension of Witt et al.'s (2008) study. They found that golfers who recently performed better perceived the golf hole as larger than those who recently performed worse. A mini-putting task towards a single black target was used in this thesis as the novel motor skill participants had to learn. Participants wore occlusion goggles and a headset that played white noise to remain consistent with the procedure for Experiment 2. True trial-by-trial feedback was provided throughout the entire experiment. However, after Block 2, participants were shown false social comparative feedback comparing their own performance to that of other participants. The purposes of this study were to first, replicate Witt et al.'s (2008) study, and secondly to determine if the belief of one's performance relative to others could still induce the perceptual bias effect similar to the bias that Witt et al. (2008) had found. Specifically, it was hypothesized that participants who were told their performance was better than other participants would estimate the target size to be larger than those who were told they were performing worse than other participants. This was predicted because past studies have shown that false positive social comparative feedback increased feelings of self-efficacy and motivation (Ávila et al., 2012; Lewthwaite & Wulf, 2010). Because visual attention to the target object was required for the action specific effect to occur (Cañal-Bruland et al., 2011), it was suggested that false positive feedback participants, who will experience an increase in motivation after receiving false feedback, will direct their visual attention to the correct target object.

Block 1 of Experiment 1 replicated Witt et al.'s (2008) study. Participants who performed better (as evidenced through lower radial errors) perceived the target size to be larger than those who performed worse. More importantly, it showed that the introduction of the goggles and the white noise did not significantly interfere with Witt et al.'s (2008) original task.

The hypothesis was not supported by the results, but there were trends to suggest that positive feedback participants experienced internal changes due to the false social comparative feedback, which may be related to more accurate target size estimations than negative feedback participants post-false social comparative feedback. It could be possible that the hypothesis wasn't supported because there was no clear object on which participants could focus their attention. There were too many secondary goals – scoring any radial error of less than 70 cm so that the putt could be valid, and successfully looking away from the putt right after the putter comes into contact with the ball. The following is a discussion of the trends that suggested the hypothesis might be more strongly supported once the secondary goals are removed.

Block 3 sought to extend Witt et al.'s (2008) findings by showing that false feedback, in the form of comparison with the performance of others, could also influence perception - independent of their true trial-by-trial performance. Ávila et al. (2012) and Lewthwaite and Wulf (2010) have shown that providing false positive social comparative feedback improved performance and learning because self-efficacy and motivation had increased. After false social comparative feedback was administered, the average radial error was no longer found to be significantly correlated to perceived target size (as it was in Block 1). Instead, the radial error of the last trial in Block 3 was significantly correlated to target size. When analyzed between groups, this correlation was found only in the positive feedback group. This suggested that after receiving positive social comparative feedback, recent performance had a stronger influence on perception. Cognitive fatigue may have made it difficult for participants to pay attention to the target size while concentrating on completing the task correctly (e.g. aiming for the target, remembering to look away from the target once they putt). However, because positive feedback participants may have put more effort into accurately estimating the size of the target, they may have attempted to overcome this divide in attention throughout Block 3 by relying more heavily on their most recent memory of it – their last trial.

While Witt et al. (2008) found a significant difference in target size perception between the easy and hard conditions, the present thesis did not find a significant difference between false positive and negative social comparative feedback groups. However, the positive feedback group had a more accurate estimation of target size, whereas the negative feedback group trended towards an overestimation bias. This may be explained by visual attention having been directed at different target objects. Positive feedback participants may have been more focused on the black target circle to more accurately perform the task, whereas negative feedback participants may have been more focused on the largest white circle to most quickly finish the experiment. Because negative feedback participants were suspected to have focused on a circle much larger than the black circle, this could explain their overestimation bias.

Self-efficacy ratings provided insight into the effects of receiving false social comparative feedback. Ratings of confidence and motivation were significantly negatively correlated to radial error only after participants received false feedback. Participants were able to interpret their performance in a context that was unavailable to them in Blocks 1 and 2. By being able to compare their performance to that of others, their feelings of self-efficacy may have been influenced through vicarious experience. This was described by Bandura (1977) as a source of self-efficacy through observing others doing the same task. Although participants did not view others putting, they were able to gauge the resultant performance and compare their own future performance to it. Thus in subsequent trials following false social comparative feedback, when participants performed poorly (high radial error) their confidence and motivation may have lowered because they may have felt they now performed worse than others (if they had received false positive feedback), or they experienced confirmation that they were indeed worse than others (if they had received false negative feedback). If participants instead performed well following false social comparative feedback, the opposite may have happened –their confidence and motivation increased because they were now performing better (if they had received false negative feedback), or they confirmed that they were indeed better than others (if they received false positive feedback).

The decrease in ratings of difficulty and the decrease in errors after receiving false positive feedback was consistent with Ávila et al.’s (2012) and Lewthwaite and Wulf’s (2010) findings that positive social comparative feedback was related to better learning. This change within the positive feedback group may have been due to the self-fulfilling prophecy phenomenon, where an increase in self-efficacy and motivation as a result of being told they were performing better than others actually led to better performance (Ávila et al., 2012). This finding that positive feedback participants had a decrease in ratings of task difficulty and a decrease in errors can serve as a manipulation check because there was a positive change in the feelings towards the task (e.g. the task felt easier after receiving false feedback) for those who were told they performed better than others. In other words, it suggested that the false belief of positive performance was successful to an extent.

Thus, there was no strong support for the hypothesis that false positive social comparative feedback introduced an overestimation bias in target size, and negative false social comparative feedback introduced an underestimation bias. However, changes in the positive feedback participants (e.g. decreased errors, decreased ratings of task difficulty) suggested that the experimental manipulations were successful to an extent. In the following experiment, feedback manipulation occurred on every trial and shifted the frame of focus to the self.

3.0 EXPERIMENT 2: Complete Dissociation between Action and Visual Feedback

The feedback in Experiment 1 was provided in an external frame of reference – participants judged their scores against the falsified average of other participants (i.e. social comparative feedback). Experiment 2 instead provided feedback in an internal frame of reference. That is, feedback was the participant's own performance, and was given trial-by-trial. This was similar to Witt et al.'s (2008) Experiments 2 and 3, where participants viewed their trial-by-trial performance in a laboratory setting.

However, Experiment 2 sought to extend Witt et al.'s (2008) findings regarding the action specific effect by testing if the effect would remain when performance outcomes were entirely separated from true motor action. It was hypothesized that action and perception were sufficiently dissociated such that the illusion of success through false positive feedback could bias perception towards more favourable properties. This was predicted because false feedback has been shown to influence feelings of self-efficacy and motivation (Ávila et al., 2012; Hu et al., in press; Lewthwaite & Wulf, 2010). When individuals are motivated, they may focus more strongly on the target. Cañal-Bruland et al. (2011) suggested that when a target was attended to, it would stand out by appearing larger. Thus those receiving false positive feedback were predicted to perceive the target (i.e. golf hole) to be larger than those in false negative feedback, regardless of their actual performance. The null hypothesis was that the action specific effect would be absent when performance outcomes were separated from true action.

Further, Experiment 2 investigated whether the false trial-by-trial feedback had an influence on learning. Schmidt and Wrisberg (2008) says one method to assessing learning is through retention and transfer tests. Retentions tests are typically administered after a break following acquisition, and its purpose is to test whether or not the improvements during acquisition are permanent. The retention tests are conducted on the same skill that was practiced during acquisition. Transfer tests assesses the adaptability of the acquired skill – whether the skill can be used and modified to suit new environments and situations. In this thesis, the transfer task was the same as the retention task, except participants putted to the target from a further distance. Because past studies have found that false positive feedback can improve performance in retention and transfer tests (Ávila et al., 2012; Lewthwaite & Wulf, 2010), it was hypothesized that the false positive feedback group in this present thesis would exhibit similar improvements.

3.1 Methods

3.1.1 Participants

Forty-three (22 male) right-handed participants aged 18 – 30 years old (*M* = 21.2, *SD* = 3.1) were recruited for the study. The same participant pool and recruitment methods as Experiment 1 were used again. They all received monetary compensations of $5 at the end of the experiment. All portions of this study were approved by the McMaster Research Ethics Board.

3.1.2 Apparatus and Materials

The apparatus and materials from Experiment 1 were used as described in Section 2.1.2, excluding the false positive and negative social comparative feedback histograms.

3.1.3 Procedure

The initial procedure remained the same as in Experiment 1 (e.g. removal of shoes, consent forms, self-efficacy questionnaire, and practice trials). Experiment 2 proceeded as follows.

Acquisition Phase

Putting Task

The timing of the goggles and the white noise were identical to Experiment 1. The white noise started playing when the participant indicated they were ready. The goggles became opaque as soon as the putter came into contact with the golf ball, and became clear again after 20 seconds (the white noise stopped after 10 seconds). During this time, their radial error was recorded. If the shot was valid, the ball was also moved to a predetermined set of locations (discussed later) before the 20 seconds was over. If the shot was invalid, the experimenter picked it up and returned it to the starting location.

The predetermined set of locations (quadrant and radial distance from the target) used to determine the falsified feedback is shown in Table 2. The quadrant randomization was not included in the table, but all participants received false feedback four times in each of the four quadrants (randomized), totalling 16 valid trials.

Table 2

Radial Distances (in centimetres) for golf ball locations in Experiment 1

	POSITIVE		NEGATIVE	
	5	20	10	40
	5	25	15	50
	10	25	20	55
	10	25	20	55
	15	30	25	60
	15	35	25	65
	15	35	30	65
	20	35	35	70
MEAN	**20.3**		**40.0**	
STDEV	**10.2**		**20.0**	
Coefficient of Variability	**0.5**		**0.5**	

All participants in a single condition received the same set of locations, in a randomized order. Participants were in one of three conditions. The first condition was the false positive feedback group, where the mean radial distance from the target was 20.3 cm (*SD* = 10.2 cm, range = 5.0 cm - 35.0 cm). The second condition was the false negative feedback group, where the mean radial distance from the target was 40.0 cm (*SD* = 20.0 cm, range = 10.0 cm - 70.0 cm). These numbers were chosen such that both conditions' scores had a coefficient of variability of approximately 0.5. The final condition was the control group, where the ball location was not manipulated, and participants received true feedback. Since Block 1 and Block 2 of Experiment 1 directly reflected the acquisition and retention phase of Experiment 2 and also did not involve moving the golf ball, participants from Experiment 1 were used as the control group of Experiment 2.

The acquisition phase ended when participants achieved 16 valid trials.

Perceptual Task

The perceptual tasks were the same as in Experiment 1. The remainder of the self-efficacy questionnaire was completed at the end (Appendix C, questions 7 - 9).

Retention Phase

The final change from the pilot study was to include both the retention and transfer phases, which were to be completed by participants approximately 24 hours after acquisition. These phases would provide insight into any learning effects. All participants completed four valid trials without goggles, white noise, or manipulations of the golf ball locations. In an attempt to remain consistent with the acquisition phase however, participants were asked to not look at the golf ball (by whatever means comfortable to them, whether it was turning around, or closing their eyes, etc.) after their putter came into contact with it. Following the four valid trials, they completed both perceptual tasks. No self-efficacy questionnaires were administered in the retention phase because no feedback manipulations were used.

Transfer Phase

Participants then completed a final four valid trials, again without goggles, white noise, or ball manipulations. This time, they putted from a distance of 5 metres away from the centre of the target. Finally, they completed the perceptual tasks once more. Again, no self-efficacy questionnaires were administered because no feedback manipulations were used.

3.1.4 Data Analysis

Data analysis was the same as in Experiment 1 except for the following differences. Because the control group as imported from Experiment 1 did not have a parallel transfer phase, non-parametric analyses were run twice – once to analyze 2 groups (positive and negative) x 3 time (acquisition, retention, transfer), and once to analyze 3 groups (positive, negative, control) x 2 time (acquisition, retention). The Kruskal-Wallis test was used to detect differences between three or more independent groups, Friedman's test was used to analyze repeated measures within three groups, the

Mann-Whitney U was used to detect differences between two independent groups, and the Wilcoxon signed rank test detected differences within two groups.

Correlations were not conducted between falsified radial error and target size perceptions. This was because all participants in the positive feedback group received the same falsified scores, but in a random order. This was the same for the negative feedback group. Because the average falsified radial error of each participant will be the same within their groups, correlations would not work.

All tests will be tested for significance with two-tails, at $\alpha < .05$.

3.2 Results

3.2.1 Skew and Outliers

Significant skew was identified on the following primary dependent variables: post-acquisition paper perception (skewness of -1.31, *SE* = 0.16), post-retention paper perception (skewness of -1.26, *SE* = 0.14), and post-transfer computer perception (skewness of 1.18, *SE* = 0.30). Because the data in the primary dependent variables were skewed, non-parametric data analyses were used.

The IQR method detected one outlier in the control group. The remaining 42 participants (22 male) were aged 18 – 30 years old (*M* = 21.3, *SD* = 3.1).

3.2.2 Acquisition: Performance and Perception with False Trial-by-Trial Feedback

Computer perceptions for all participants regardless of group were not significantly correlated with true radial error, $r_s(40) = -.05$, $p > .05$ (see Figure 13). This may have been because participants had no access to their true radial error and since they were all novices, they may have not been able to judge their performance accurately through motor feedback alone. Thus it was possible that a belief of success or failure was not induced.

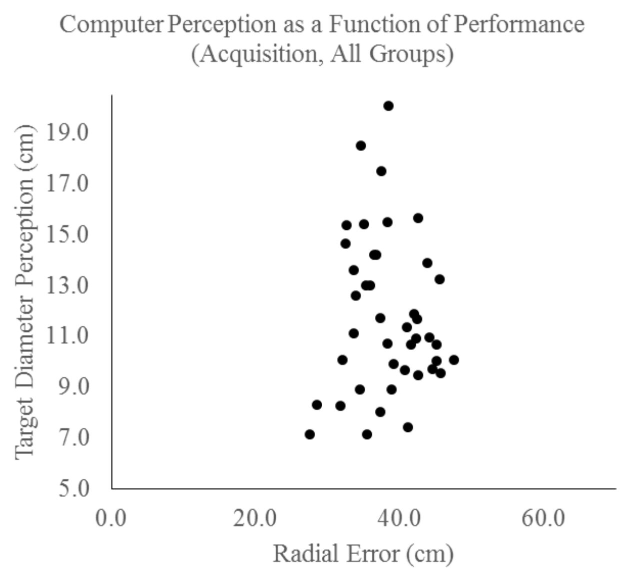

Figure 13. **Computer perception was not correlated to radial error when collapsed across group in acquisition.**

Because participants may have noticed inconsistencies between visual feedback and their motor actions, they may have searched for an alternate source of feedback. One possible source was with errors. This was because participants were informed of every time a putt was invalid. As speculated, the amount of errors was found to be significantly correlated with target size estimations in the positive feedback group, and marginally significant in the negative feedback group (see Figure 14 and Table 3).

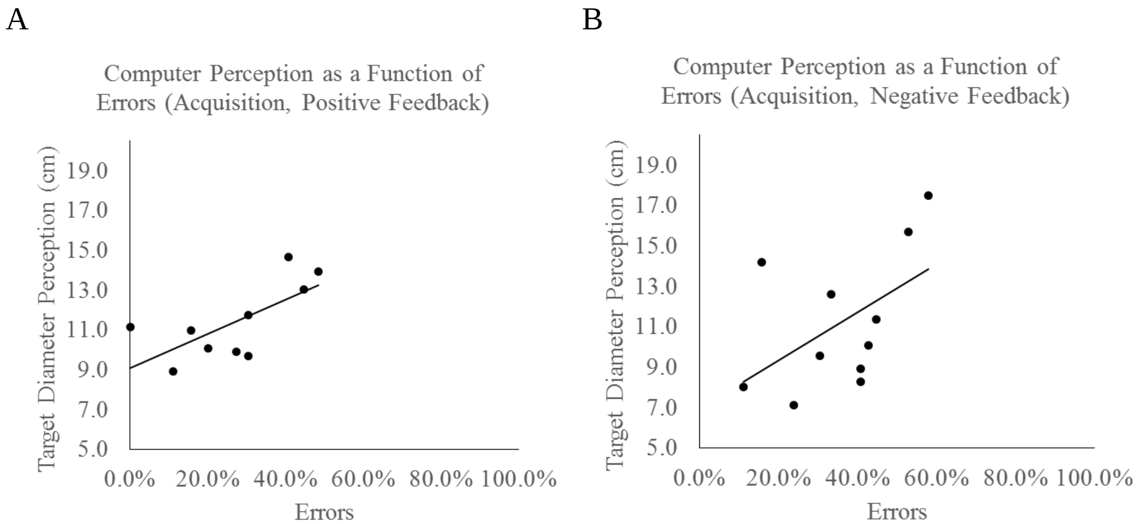

***Figure 14*. Post-acquisition perception was positively correlated to the number of errors in both the positive (A) and negative (B) feedback groups. See Table 3 for medians and correlation values.**

Table 3.

Medians and correlation values for Figure 14; post-acquisition perceptions correlated with errors in positive and negative feedback groups.

Graph	Feedback Group	Perception Median	Errors Median	Correlation
14 A	Positive	11.1 cm	29%	$r_s(8) = .63, p = .05$
14 B	Negative	10.1 cm	41%	$r_s(9) = .59, p = .06$

To further investigate whether participants were judging their performance based on the number of errors rather than radial error, correlations between self-efficacy ratings from the questionnaire and both errors and radial error were run. Consistent with our speculations, post-acquisition ratings of difficulty (*Mdn* = 60%) were positively correlated to the amount of errors (*Mdn* = 33%), $r_s(40) = .31$, $p < .05$, but not to true radial error (*Mdn* = 38.3 cm), $r_s(40) = .20$, $p > .05$ (see Figure 15). Interestingly, neither confidence nor motivation were correlated to the amount of errors or radial error. This may have been due to the wording of the questions in the questionnaire (Appendix C), where questions seven and eight primed participants to consider their performance over a longer term ("[…] rate […] how confident/motivated you were to successfully learn the golfing putting task and reproduce it at a later time."). Thus, participants may have based their ratings off of how accurately they putted towards the black target circle. However, because participants were potentially noticing an inconsistency between their visual feedback and motor actions, they may have reflected about how unable they were to predict their outcome based on their motor feedback. The wording in question nine regarding feelings of difficulty however, might not have primed participants to think of future engagements in putting, and instead had them reflect on their present experience ("[…] rate […] how difficult you thought the golf putting task was."). Thus, in considering how difficult the task was, they may have only reflected on how difficult it was to putt valid trials to finish the experiment. Hence the significant correlation between ratings of difficulty and errors, and the absence of significant correlations between confidence and motivation and measures of performance may provide support for our speculation that participants may have judged their performance on the number of errors because it was more reliable than radial error.

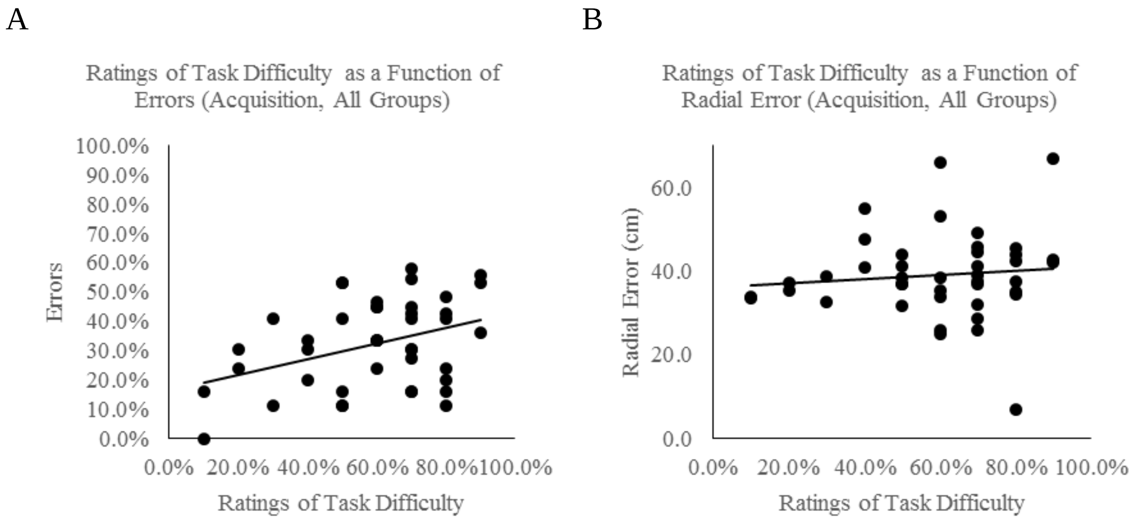

Figure 15. **Ratings of task difficulty post-acquisition was correlated to the amount of errors (A), but not to radial error (B).**

Although there were significant correlations between errors and computer perception for the positive and negative feedback group, there were no significant correlations between performance and perception in the control group. This may have been because they didn't receive any false feedback which may have influenced their intentions. As such, there may have been inconsistencies within the group as to which object to direct visual attention towards. For instance, because the positive feedback group may have felt more confident as a result of the feedback, they may have focused more strongly on the black target circle. Those in the negative feedback group may have noticed their putts were further from the target, and may have changed their focus to the largest white circle (to obtain the required amount of valid putts). For the control group, it was uncertain what they may have directed their visual attention towards because the absence of false feedback meant there was no change in saliency of any particular goal. For instance, some may have decided to put effort towards increasing their accuracy to the black target, whereas some others may have been aiming to obtain the required amount of valid trials as quickly as possible. Individual participants' perceptions of the target size within the control group may have thus been confounded by the lack of a clear target on which to focus their visual attention.

A 3 group (positive, negative, control) x 1 computer perception Kruskal-Wallis test was run to analyze target size estimation differences between groups. Although there were no significant differences (see Figure 16), the positive feedback group had a smaller range of responses, whereas the control group had the largest range of responses. This may be consistent with our previous speculations regarding visual attention. The majority of positive feedback participants may have grown more confident as trials progressed, so they may have put more effort into aiming for the black target circle (and thus focusing visual attention onto it). The large range in the negative feedback group may have been because some participants may have felt the task to be too difficult and started aiming instead for the minimum score required for a valid trial – the largest white circle. This may have induced an overestimation bias in some of the negative feedback participants, thus increasing the range of target size estimations. The control group, as previously discussed, had no feedback to influence on which target object to direct their visual attention, thus their range of target size estimations was the largest.

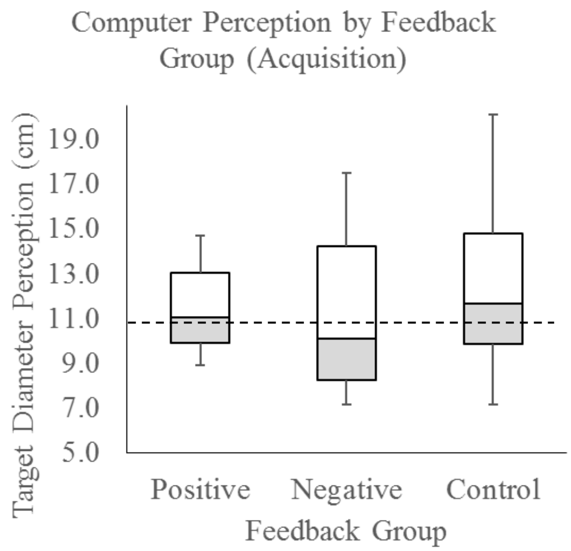

Figure 16. **Computer perception post-acquisition by feedback group. The dashed line indicates the actual target size (10.8 cm).**

To investigate whether the trial-by-trial false feedback had an effect on self-efficacy, a 3 group (positive, negative, control) x 1 time (post-acquisition) Kruskal-Wallis was run for each item on the questionnaire (confidence, motivation, difficulty). Positive feedback participants (*Mdn* = 70%) were significantly more confident, χ^2 (2) = 7.48, $p < .05$, than negative feedback participants (*Mdn* = 50%) post-acquisition (see Figure 17). Likewise, positive feedback participants (*Mdn* = 40%) rated the acquisition task as significantly less difficult, χ^2 (2) = 7.08, p < .05, than negative feedback participants (*Mdn* = 70%) (see Figure 18). This was consistent with past studies that showed false positive feedback can increase levels of self-efficacy (Ávila et al., 2012; Hu et al., in press; Lewthwaite & Wulf, 2010).

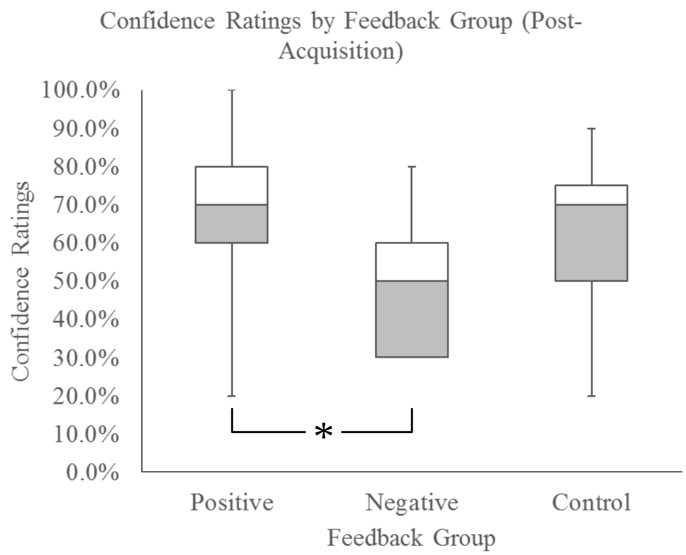

Figure 17. **Confidence ratings post acquisition by feedback group.**

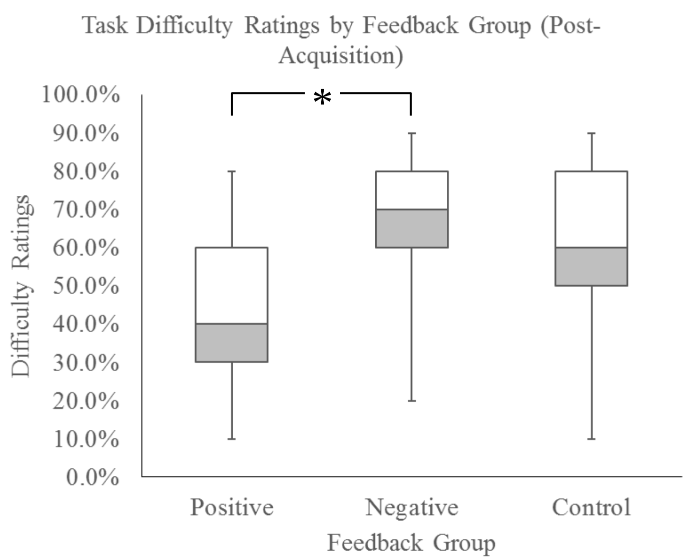

Figure 18. **Task difficulty ratings post acquisition by feedback group.**

Two previous trial analyses were conducted to determine if error correction was done on the previous trial's real outcome, or the falsified outcome. This may provide insight into whether participants believed the false feedback, and whether they were still able to use their motor feedback to gauge performance.

The first analysis was done on the effect of the real previous trial on the current real trial. A 1 group (collapsed across positive, negative, and control groups) x 4 trial type (OO, OU, UO, UU) Kruskal-Wallis found that UU (Mdn = 12%) occurred the least frequently (Mdn_{OO} = 30%, Mdn_{OU} = 21%, Mdn_{UO} = 26%), χ^2 (3) = 54.4, p < .05. OU also occurred significantly less than both UO and OO, χ^2 (3) = 54.4, p < .05. Please see Figure 19 for a graph of real previous trial followed by current real trial. These results trended towards a similar pattern as the previous trial analysis completed on Experiment 1, Block 1. That is, when participants had an undershoot, they were more successfully able to correct for it by overshooting in the next trial. However, when participants overshot, they were more likely to repeat the error. As speculated earlier, undershoots may have been easier to correct because participants could make a fair estimate about the relationship between the power behind a gentle swing of the putter and the resulting distance (i.e. the distance could only have been somewhere between the starting line of the putt and the outer-most white circle). Overshoots were more difficult to learn from because the interruption of the golf ball against the bumper made it impossible to estimate the relationship between the power behind a stronger swing and the resulting distance.

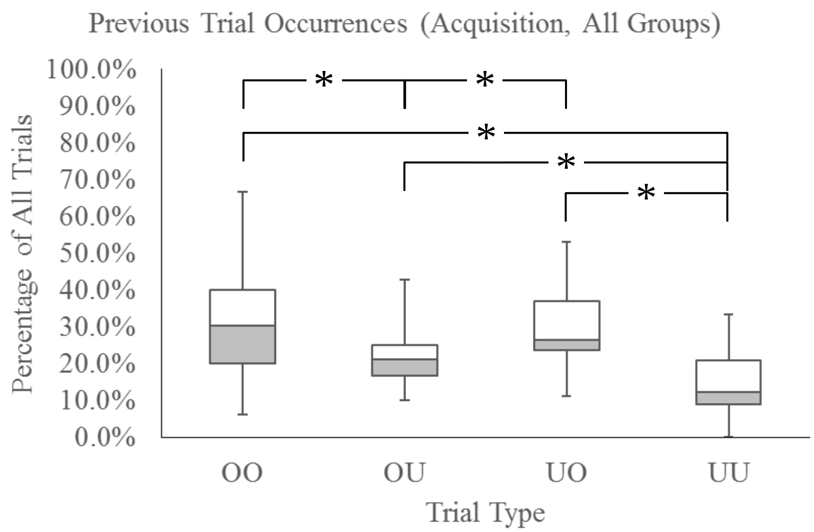

Figure 19. Occurrence of (real) previous trial types in acquisition, collapsed across group.

The second previous trial analysis was on the effect of a fake previous trial on a current real trial. A 1 group (collapsed only across positive and negative groups because the control group did not receive false feedback) x 4 trial type Kruskal-Wallis found no significant differences. This supported the possibility that participants were not using the false trial-by-trial feedback because they may have detected inconsistencies. Instead, their motor feedback may have provided sufficient feedback regarding overshoots or undershoots – and, participants were able to access that information for error correction.

To detect differences in previous trial influences *between* participants, the two previous trial analyses that were previously reported for full-group analysis were conducted again. The 3 group (positive, negative, control) x 1 trial type Kruskal-Wallis (ran once per trial type) on the effect of the real previous trial on the current real trial found no significant differences between groups for neither the OO trial type nor the UU trial type (Figures 20 A and D). The large number of OO trial types were again speculated to be a symptom of the golf balls' trajectories being interrupted by the bumper. The bumper may have made it difficult for participants to gauge how much power to decrease in their swing. The universally low number of UU trial types could be due to the fact that there was no interruption in the trajectory, so participants could make a fairly good guess at how far their golf ball travelled, and adjust accordingly.

The control group (*Mdn* = 22%) had a significantly higher percentage of OU trials, χ^2 (2) = 6.73, $p < .05$, than the negative feedback group (*Mdn* = 17%), and trended towards having more than the positive feedback group (see Figure 20 B). This may be because when either of the false feedback groups putted a valid overshoot trial, they were more likely than the control group to have the ball re-located such that the successful correction for an overshoot was more difficult to achieve (e.g. placed on a location to suggest an undershoot).

Interestingly, the control group had a significantly lower percentage of UO trials, χ^2 (2) = 10.91, $p < .05$ than the positive feedback group (*Mdn* = 38%), and trended towards having less than the negative feedback group as well (see Figure 20 C). This was unexpected because the control group had true trial-by-trial feedback, which should allow for better correction for both overshoots (as evidenced by OU trials) and undershoots (UO trials). However, the current data suggested that they were less likely than the positive and negative feedback group to successfully correct for an undershoot. There may be various confounds that make this result difficult to explain. For instance, perhaps control participants placed less importance on correcting undershoots because they didn't occur as often as overshoots. Or, perhaps the positive and negative feedback participants focused more strongly on correcting undershoots *because* they were better able to estimate the distance travelled than overshoots. Thus, because it was difficult to discern participants' intentions, the reason for control feedback participants having significantly less UO trials than the other feedback groups was uncertain.

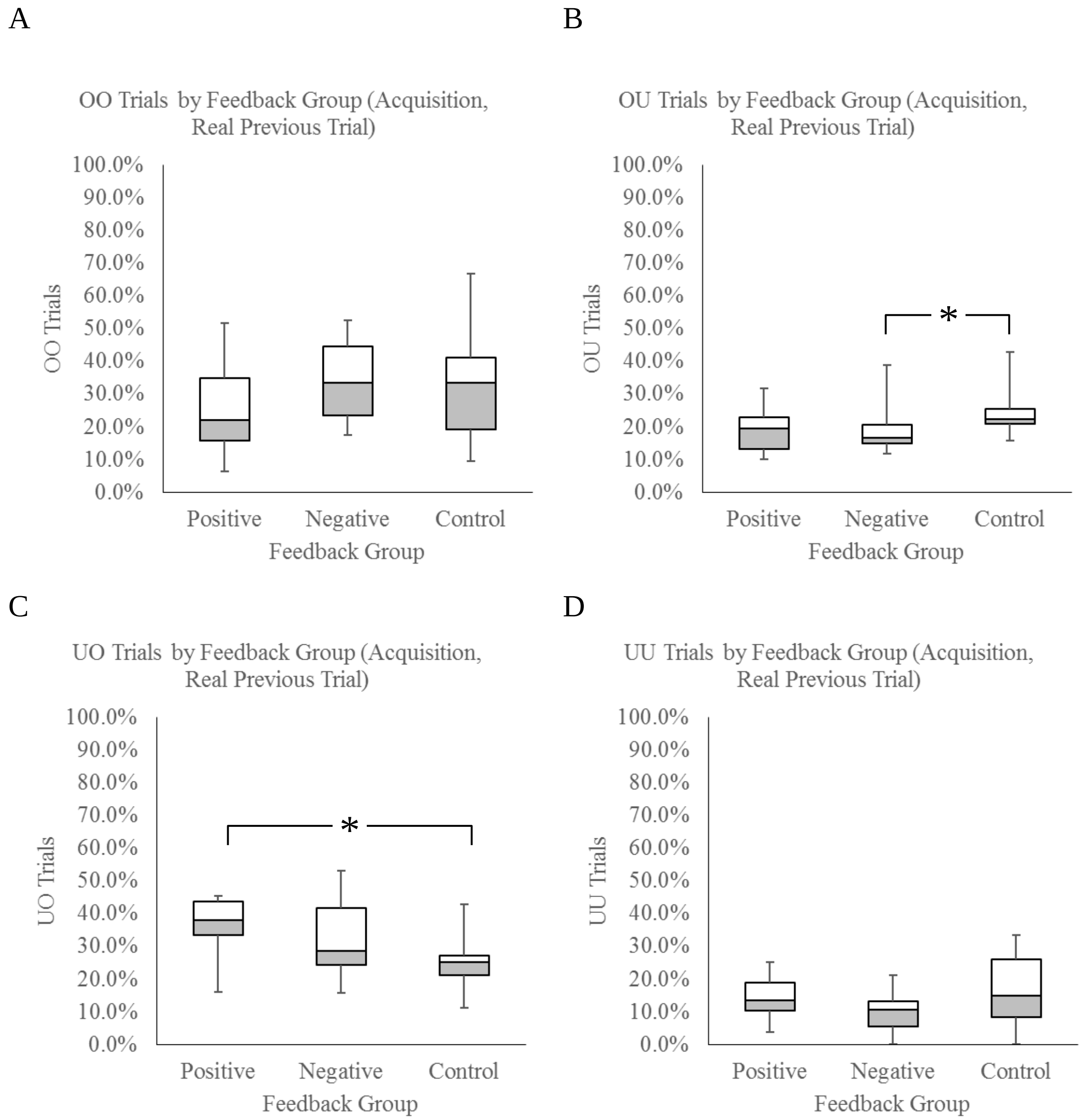

Figure 20. **Graphs of real previous trial occurrences by feedback group during acquisition. Graph A is for OO, B is for OU, C is for UO, and D is for UU.**

The second previous trial analysis was the effect of a fake previous trial on a current real trial. Because the control group did not receive any falsified results, the Mann-Whitney U was done only on the positive and negative feedback groups. There were no significant differences in the frequency of each previous trial type between groups. Consistent with the earlier analysis that was collapsed across all groups, the absence of significant differences suggest that neither the positive nor the negative feedback participants were using the false feedback in their error correction strategies. This may have been because they noticed inconsistencies between the available visual feedback and their motor feedback.

3.2.3 Retention: True Trial-by-Trial Feedback and Removal of Goggles and White Noise

The retention phase differed from the acquisition phase in that the trial-by-trial feedback participants received were their true performance, and they no longer wore the goggles nor the headset. The retention phase ended after four valid trials.

Similarly to the results from the acquisition phase, target size perceptions were not significantly correlated to radial error, but instead to the amount of errors (see Figure 21.1). Although they had access to veridical feedback, it appeared that participants had learned to rely on invalid trials for feedback.

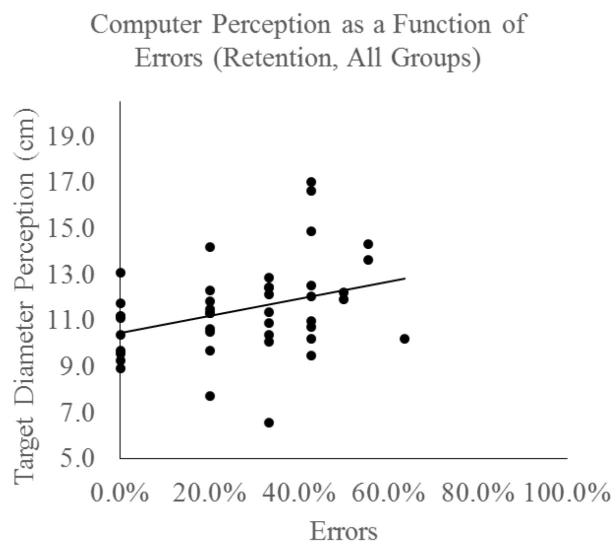

***Figure 21.1*. Post-retention computer perception was positively correlated to the number of errors when collapsed across group. See Table 4 for medians and correlation values.**

When divided by groups, however, this positive correlation was found only in the negative feedback group (see Figure 21.2 B and Table 4). It was expected that control feedback participants (see Figure 21.2 C) would not have a correlation with errors because they never had to find an alternate source of feedback (since they received true trial-by-trial feedback in acquisition). Neither positive feedback participant's radial error nor number of errors were significantly correlated with computer perception. Similarly to the speculations as to why there were no significant correlations in Block 2 of Experiment 1, although positive feedback participants may have had enough motivation to start readjusting to using radial error as a reliable source of feedback, there was not enough time (four valid trials). They may have started to shift their attention away from the errors and just started to take advantage of the newly introduced veridical feedback – thus not effectively making use of either. Interestingly, the negative feedback group's significant correlation between errors and perception suggested that unlike the positive feedback group, they remained reliant on this alternate source of feedback, despite the presence and availability of veridical trial-by-trial feedback. If as speculated, negative feedback participants had shifted their goal to completing the experiment instead of increasing accuracy, then the number of errors remained a more salient variable than radial error. Hence, the continued focus of attention on errors.

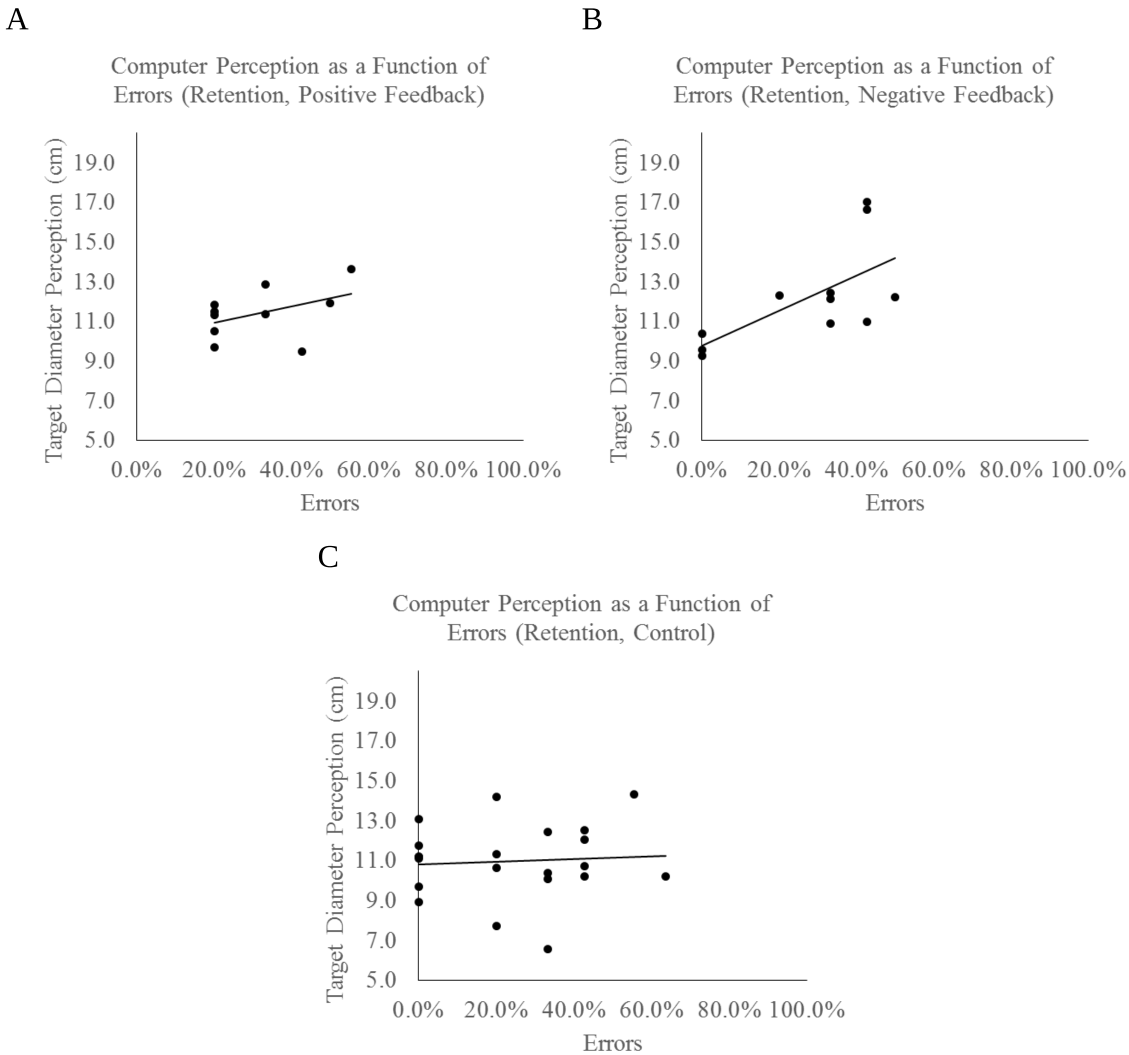

***Figure 21.2.* Post-retention computer perception correlations with errors for the positive (A), negative (B), and control (C) groups. See Table 4 for medians and correlation values.**

Table 4.

Medians and correlation values for Figures 21.1 and 21.2; post-retention perceptions correlated with errors collapsed across group and in negative feedback groups.

Graph	Group	Perception Median	Errors Median	Correlation
21.1	All	11.3 cm	33%	$r_s(40) = .33, p < .05$
21.2 A	Positive	11.4 cm	27%	$r_s(8) = .45, p > .05$
21.2 B	Negative	12.1 cm	33%	$r_s(9) = .68, p < .05$
21.2 C	Control	11.1 cm	27%	$r_s(19) = .07, p > .05$

The 3 group (positive, negative, control) x 1 computer perception Kruskal-Wallis found no significant differences in computer perception between groups (see Figure 22). However, the trends in target size perceptions were consistent with the speculations introduced in the data analysis for the acquisition phase. The positive feedback group consistently had the smallest range in computer perception, which was potentially due to an increased effort in focusing on the black target circle and in more accurately estimating the target size. The trend towards overestimation in the negative feedback group may still have been a result of a shift in goals – an increased focus on the largest white circle to more quickly achieve four valid putts. This may have biased their target size estimations to be larger. It was more difficult to make an educated guess as to what the control group had been focusing on. As a group, they had not received any false feedback which could influence motivation and levels of effort. Compared to their computer perception in acquisition however (Mdn = 11.8 cm), they had a significant decrease in target size estimations ($Mdn_{\text{Retention}}$ = 11.1 cm), Wilcoxon signed-rank, $Z = -2.00$, $p < .05$. This suggested that those in the control group who had been focusing on completing the experiment may have started to focus on the black target circle in retention. Because participants had returned to complete the retention and transfer phases 24 hours after the acquisition phase, and because the retention phase ended after four valid trials, control participants may have not been experiencing as much fatigue, and thus their target focus may have not yet shifted to the largest white circle.

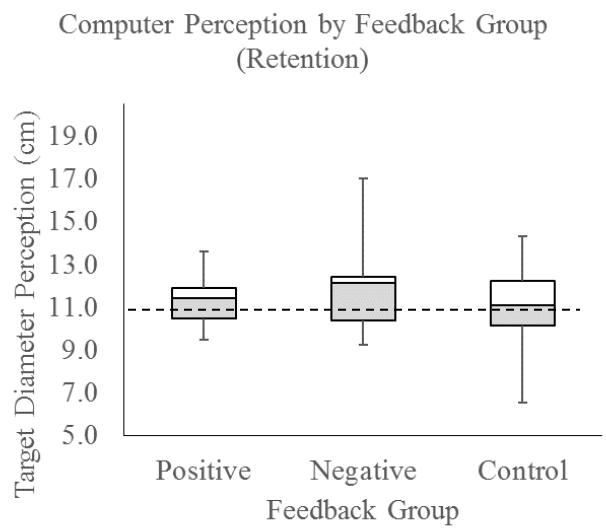

Figure 22. **Computer perception post-retention by feedback group. The dashed line indicates the actual target size (10.8 cm).**

Both the 1 group (collapsed across feedback groups) x 4 trial type (OO, OU, UO, UU) Kruskal-Wallis test and the four 3 group (positive, negative, control) x 1 trial type Kruskal-Wallis tests run for each previous trial type found no significant differences in the frequencies of each trial type across all groups and between groups. Because Block 2 of Experiment 1 and the retention phase of Experiment 2 reflected each other, this finding was consistent with the explanation for Block 2's absence of significant differences in the previous trial analysis. That is, there was a significant change in the procedure (i.e. removal of the goggles and headset, and as a result, the introduction of true trial-by-trial feedback and the requirement of manually looking away from the golf ball as soon as their putter comes into contact with it), but insufficient time to adapt to the change (i.e. four valid trials). Thus, it was suspected that because the participants were still adapting, they may have not revised their error correction strategies to match the new situation.

3.2.4 Transfer: Putting from a New Distance

The task for participants was the same as in retention except they would putt from a distance of 5 metres instead of 3. The transfer phase ended after four valid putts. Only those in the positive and negative feedback group participated in this phase.

There were no significant correlations between performance and perception variables when analyzed across group, and when each feedback group was analyzed separately (see Table 5.1 and 5.2). Because the Mann-Whitney U tests (run to detect differences in performance and perception between groups) also found no significant differences, this absence of correlation could be explained similarly to retention – that there was a change in the procedure (i.e. change in distance), and not enough time to adapt. However, there were some trends to indicate that the feedback manipulations had been successful to an extent. The following is a discussion of the trends.

Table 5.1.

Medians and correlation values for correlations between radial error and computer perception in the transfer phase.

Group	Perception Median	Radial Error Median	Correlation
All	10.8 cm	35.8 cm	$r_s(19) = .09, p > .05$
Positive	10.7 cm	34.5 cm	$r_s(8) = -.22, p > .05$
Negative	11.3 cm	36.8 cm	$r_s(9) = .36, p > .05$

Table 5.2.

Medians and correlation values for correlations between errors and computer perception in the transfer phase.

Group	Perception Median	Errors Median	Correlation
All	10.8 cm	43%	$r_s(19) = .23, p > .05$
Positive	10.7 cm	46%	$r_s(8) = .31, p > .05$
Negative	11.3 cm	43%	$r_s(9) = .12, p > .05$

There were no significant differences in target size estimations between groups, Mann-Whitney U, $Z = 0.56$, $p > .05$, $r = 0.3$ (see Figure 23). However, the trend across the three time points (acquisition, retention, transfer) was that the interquartile range decreased over time. This could be a result of increased exposure to the black target circle (participants were aware they would have to estimate the target size after each phase). The positive feedback group’s IQR was consistently smaller than the negative feedback group’s, possibly because the positive feedback group was more unanimously focused on the black target circle. In the transfer phase, the median target size estimation of the positive feedback group (10.7 cm) was almost exactly the size of the actual target (10.8 cm).

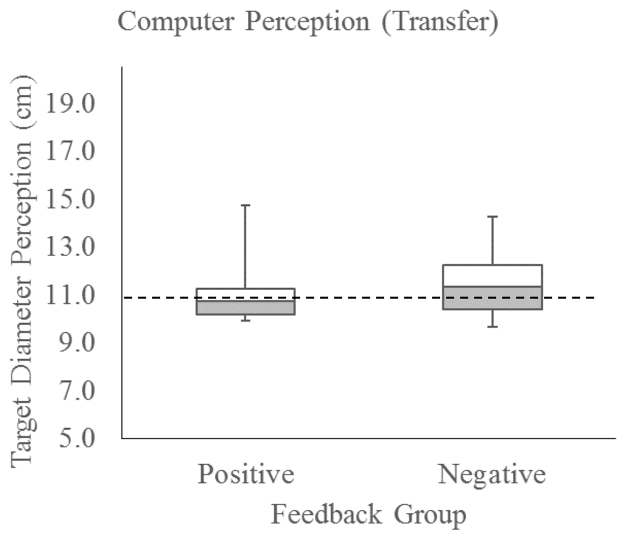

Figure 23. **Computer perception post-transfer by feedback group. The dashed line indicates the actual target size (10.8 cm).**

The previous trial analysis provided a stronger indicator of the lasting effects of false feedback. When collapsed across group, the 1 group x 4 trial types (OO, OU, UO, UU) Kruskal-Wallis found the frequency of OO (*Mdn* = 0%) trials to be significantly less than OU (*Mdn* = 25%), UO (*Mdn* = 25%), and UU (*Mdn* = 29%) trials, χ^2 (3) = 20.72, $p < .05$ (see Figure 24.1). This was likely due to the nature of the change in procedure in transfer. Because participants had spent acquisition and retention putting from a closer distance, any error correction strategies they had developed would have made it more likely for them to undershoot when putting from a further distance.

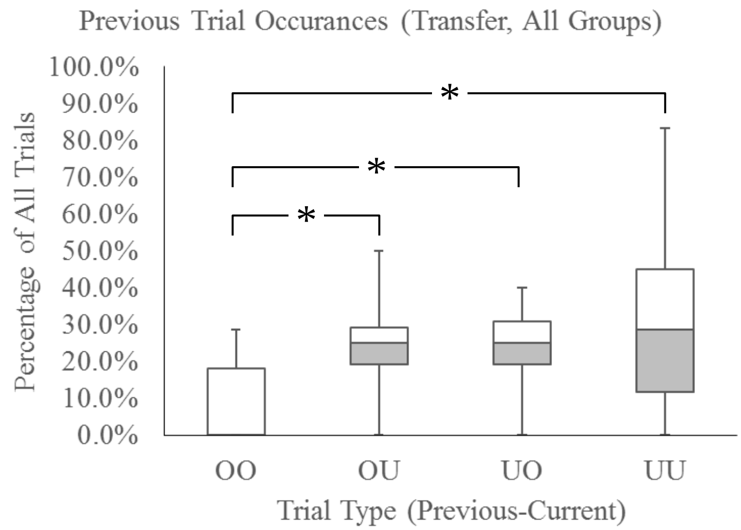

***Figure 24.1*. Previous trial analysis collapsed across group found OO to occur significantly less frequently than OU, UO, and UU.**

A 2 group (positive, negative) x 1 trial type Mann-Whitney U test was run for each trial type to test for differences between groups. Positive feedback participants had more instances of both UO (*Mdn* = 29%), $Z = -2.18$, $p < .05$, $r = 0.02$, and OU (*Mdn* = 29%) trials, $Z = -2.75$, $p < .01$, $r = 0.02$, than negative feedback participants (Mdn_{UO} = 20%, Mdn_{OU} = 20%). Conversely, negative feedback participants (*Mdn* = 40%) had more instances of UU trials, $Z = 2.25$, $p < .05$, $r = 0.02$, than positive feedback participants (*Mdn* = 15%). See Figure 24.2 for graphs of previous trials. Past studies have found lasting benefits to receiving false positive feedback – better performance during acquisition (Lewthwaite & Wulf, 2010), and retention (Ávila et al., 2012; Lewthwaite & Wulf, 2010). A higher percentage of OU and UO trials implied better error correction strategies, whereas a higher percentage of OO and UU trials implied more poorly developed error correction strategies. Thus the positive feedback group having more OU and UO trials (and significantly less UU trials) in the transfer phase was consistent with past studies that suggested there were lasting learning benefits to false positive feedback.

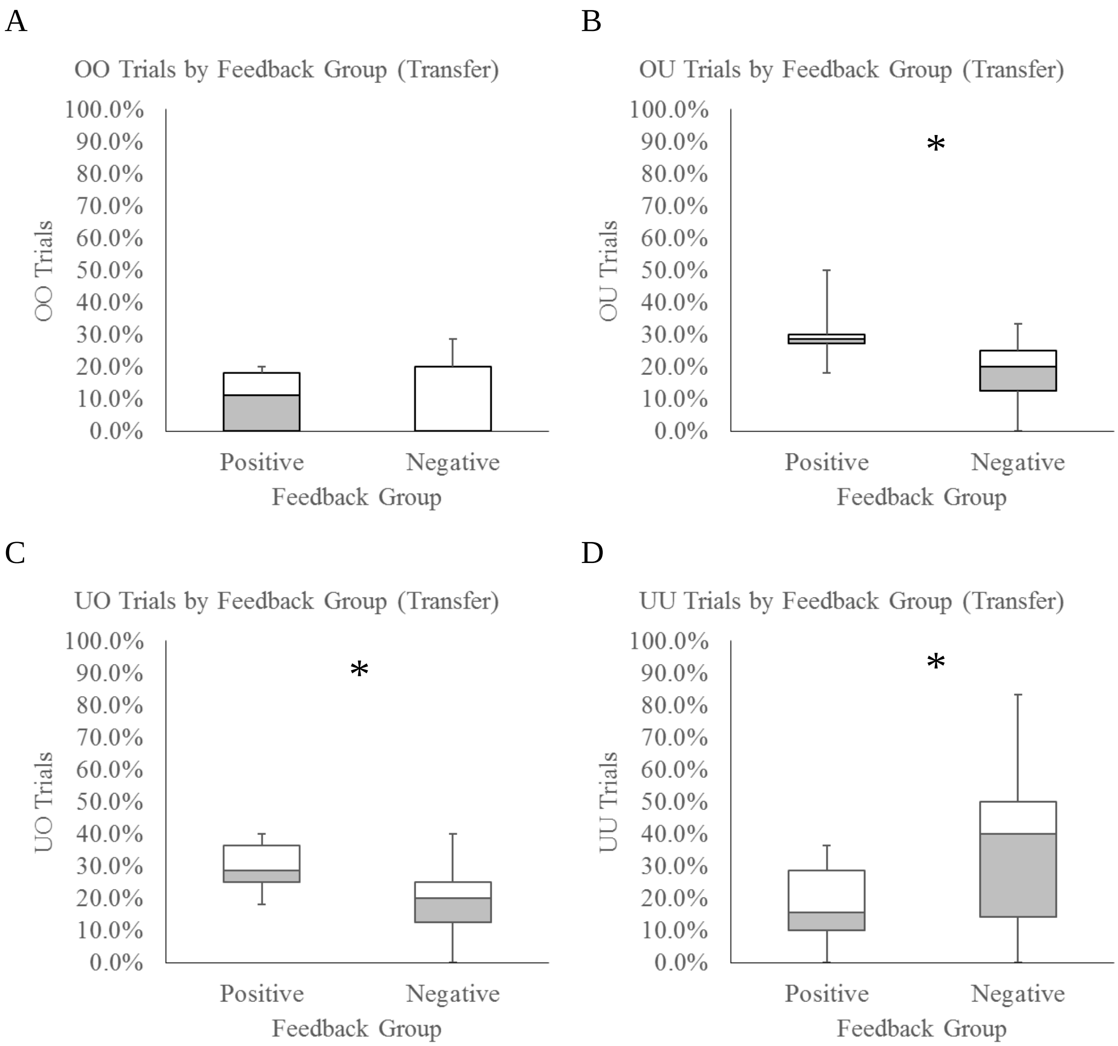

***Figure 24.2.* Occurrence of OO (A) trials, OU (B) trials, UO (C) trials, and UU (D) trials by feedback group in the transfer phase.**

3.3 Discussion

The purpose of Experiment 2 was to extend Witt et al.'s (2008) findings by investigating whether the action specific effect would still occur when performance outcomes were entirely separated from true action. A putting task similar to Experiment 1's task was used. This time, trial-to-trial feedback was falsified, and social comparative feedback was not used. After participants putted, the experimenter secretly moved their golf ball to predetermined locations closer (i.e. positive feedback group) or further (i.e. negative feedback group) to the golf hole – regardless of their actual performance. In order to be able to successfully move the golf ball without the participants' knowledge, they wore occlusion goggles and listened to white noise (the timing of the equipment was illustrated in Figure 2). False positive feedback has been shown to increase feelings of self-efficacy (Hu et al., in press), which may motivate an individual to increase the amount of effort exerted into acquiring a novel motor skill (Ávila et al., 2012; Bandura, 1982). This increased effort may improve performance (Ávila et al., 2012), as well as increase target size estimations through increased attentional focus on the target (Cañal-Bruland et al., 2011). Thus, it was hypothesized that action and perception were sufficiently dissociated such that the belief of success (through false positive feedback) would lead to larger target size estimations, and the belief of failure (through false negative feedback) would lead to smaller target size estimations. This hypothesis was not supported, and the following is a discussion of the results and confounds.

Retention and transfer phases were introduced to assess the degree of permanence and adaptability, respectively. As suggested by past studies (Ávila et al., 2012; Lewthwaite & Wulf, 2010), it was predicted that the false positive feedback group would perform better than the false negative feedback group.

Target size estimations were not significantly correlated to radial error for any feedback group at any point in time (acquisition, retention, transfer), but was instead correlated to the number of errors. It was speculated that participants may have noticed a discrepancy between the visual feedback that was provided, and their motor feedback. Thus, they may have sought a more reliable source of feedback regarding their performance, which was through invalid trials. However, the amount of errors were significantly *positively* correlated to target size in acquisition for the positive and negative feedback groups. This was unexpected because it was predicted that as performance decreased (larger amounts of errors), target size estimations were hypothesized to decrease – in other words, negative correlations as opposed to positive. It was speculated that this may have been a result of the requirement to achieve a certain number of valid trials before the experiment ended. To elaborate, as more errors were putted, participants may have felt an increasing pressure to putt shots that landed within the boundaries of the largest white circle, rather than within the black target circle. Thus, because visual attention was focused on a circle which had a diameter of 70 cm, their target perceptions may have been biased towards overestimation. This may have led to the positive correlation between target perception and the amount of errors.

Another finding that was consistent with our speculations that participants sought an alternate source of feedback on which to judge their performance was that their ratings of task difficulty were positively correlated to the amount of errors but not to true radial error. Further, previous trial analyses can help provide insight into improvements in skill (e.g. the development of error correction strategies). While there were significant differences between the frequencies of the four previous *real* trial types (indicating various levels of error correction strategies), there were no significant differences when the four previous *false* trial types were analyzed. This suggested that participants were not relying heavily on the trial-by-trial feedback that was provided (and falsified), and thus may be further evidence that participants noticed that radial error was not a reliable source of feedback.

Although there were no significant differences in target size perceptions between groups at any time point (acquisition, retention, transfer), the positive feedback group consistently had the smallest range of target size estimations. This may have been because the increase in self-efficacy (as suggested by lower ratings of task difficulty and higher ratings of confidence) led to a greater focus on the target as a whole group. Since there was a greater chance that they attended to the black target (as opposed to how anxious they were feeling, how comfortable the occlusion goggles and headset felt, etc.), target size estimations were more consistent with other participants within the group. The negative feedback group trended towards overestimations, and this may have been due to a shift in their goals. Because they did not experience an increase in self-efficacy, they may have shifted their efforts away from decreasing their accuracy, to finishing the experiment as soon as possible. The experiment ended after a certain number of valid putts were achieved, so negative feedback participants may have started to focus more on the largest white circle (i.e. our definition of a valid putt). Since the minimum required radial error for a valid trial was much larger than the black target circle, this may have introduced an overestimation bias. The control group often had a wide range of target size estimations, and this may have been because they didn't receive false feedback that may have universally influenced which goal they prioritized (landing on the black target circle, or landing within a valid radial error).

The self-efficacy questionnaire and previous trial analyses provided some insight into the effectiveness of the manipulations. Compared to negative feedback participants, positive feedback participants indeed reported themselves to be more confident and found the task to be less difficult post-acquisition. This was supported by previous research that found false positive feedback to lead to higher levels of self-efficacy (Hu et al., in press). Over time (acquisition, retention, transfer) however, there were no significant differences in confidence and motivation ratings within groups. This was an unexpected finding because false positive feedback had been found to increase levels of self-efficacy (Hu et al., in press). It was possible that participants may have detected a discrepancy between their actions and the visual feedback they were receiving, which may have caused them to be uncertain about their actual performance.

Positive feedback participants appeared to have developed better error correction strategies (as suggested by greater OU and UO trials than negative feedback participants) than negative feedback participants (who had greater OO and UU trials). This may be explained by the self-fulfilling prophecy. When receiving feedback that suggested they were performing well, positive feedback participants may have been more motivated to learn from their mistakes. When receiving feedback that suggested they were performing poorly, participants may have started to get distracted and focused on other things, which made it difficult to learn from their mistakes.

Thus, although the belief of success or failure appeared to have been effective enough to influence the participants consciously (differences in levels of self-efficacy, some evidence of differing levels of error correction strategies), it was suspected that completely separating true motor action from visual feedback reversed perceptual biases (i.e. belief in better performance was correlated to *smaller* target size estimations). This may have been because the more poorly participants performed, the more likely they were to shift their focus of visual attention to the largest white circle.

5.0 General Discussion

Witt et al. (2008) found recent performance in certain motor tasks was related to perception: those who recently performed well on that task perceived the object of that skill (e.g. hole size in a golf putting task) to be larger than those who performed more poorly. Experiment 1 in this thesis was able to replicate this finding in Block 1. We also sought to extend these findings (e.g. Witt et al., 2008) by providing goal/task specific feedback in an external frame of reference by falsely informing participants, independent of their actual performance, that they were performing either better or worse than other participants. It was hypothesized that those who were performing "well" (now determined by how they were simply told their performance compared to others) would perceive the target size to be larger than those who were performing worse. Our goal here was to determine whether the perceptual biasing effects demonstrated by Witt et al. (2008), and confirmed in Block 1 of our first study, were localized within a general internal representation of "success" that was generated independent of actual motor performance. This hypothesis was not supported. Specifically, performance on the size matching tasks did not differ as a function of feedback group except in very specific instances. For example, although positive feedback participants experienced improvements in performance in Block 3 (decrease in errors, decrease in difficulty ratings), there were no correlations between radial error and perception. Instead, there was a correlation between the radial error of their last trial in Block 3 and perception. This may be due to a combination of increased motivation (from receiving positive feedback) and fatigue. By the time participants completed Block 3, they were aware that they would have to estimate the size of the target. However, due to the complexities of the task (e.g. concentrating on the target, but also remembering to not look at their follow-through and results as soon as their putter came into contact with the golf ball), it may have been difficult to survey and remember the size of the target after each successful putt. Thus, when they were completing the size estimation task for the final time, they may have heavily relied on their last experience with the target. Negative feedback participants had no changes in errors nor difficulty ratings. There was also no correlation between performance and perception. Past studies have shown that false positive feedback increased confidence and motivation (Ávila et al., 2012; Hu et al., in press; Lewthwaite & Wulf, 2010). Because negative feedback participants did not show this increase in self-efficacy, they may not have been as motivated as positive feedback participants to accurately estimate the size of the target.

Experiment 2 provided feedback within a participant centered internal frame of reference. True motor action on every trial in acquisition was completely dissociated from performance outcome by secretly moving participants' golf balls to pre-determined locations (entirely independent of true performance). Those who received false positive feedback had their balls moved closer to the target, and were predicted to perceive the target size as larger than those who received false negative feedback (they had their balls moved further from the target).

Although a perceptual bias was induced, it was in the opposite direction of what was expected. Specifically, those who made more errors perceived the target as *larger* than those who made fewer errors (it was suspected that participants gauged their performance on the number of errors rather than radial error because it was a more reliable source of feedback). This positive correlation may have been due to a shift in visual attention away from the black target circle to the largest white circle which marked the boundaries of a valid trial. As discussed previously (section 3.3), it was suspected that as the number of errors increased, participants may have changed their goal. Instead of aiming for the black target circle, they may have aimed for the largest white circle to more quickly accumulate the required number of trials before the experiment could conclude. Because the largest white circle has a much larger diameter than the black target circle, target size estimations may have been biased towards overestimation.

There were no significant differences in confidence and motivation ratings within feedback groups over time (acquisition, retention, then transfer). One possible reason for this lack of change could be that participants were able to detect that the visual feedback didn't accurately reflect their motor actions. It was speculated that they were able to detect this because the performance outcome they saw didn't match the outcome predictions they were able to make using their motor feedback. The first few times their predictions weren't "correct" may have been believable, but after numerous trials, they may have noticed that either their predictions weren't reliable, or the performance outcomes they saw weren't reliable. Because of this, they may have been uncertain how their performance would appear in the future phases.

Thus, completely dissociating true action from visual feedback may have weakened the perceptual effect found in Witt et al.'s (2008) study. Further, it was possible that the instructions (putting a certain number of valid putts) introduced a confound by influencing where participants directed their visual attention.

One possible follow-up study would be to provide false trial-by-trial feedback that is relative to participants' true outcomes. This manipulation offers an important theoretical modification to Experiment 2. Recall that in Experiment 2, participant's actual motor activity/performance in the task was wholly disregarded. That is, any "performance" based feedback participants received (either positive or negative) was fully dissociated from what they actually did. Under these conditions, it was impossible for participants to associate knowledge of performance on any given trial with the execution of the motor plans that ultimately led to that performance. The ambiguity of results in Experiment 2 likely suggested that performers must be able to bind the internal, proprioceptively generated knowledge of what they did (motor component) with outcome (performance component). To respect this link while attempting to make participants believe in either successful or unsuccessful performances, false feedback in the follow-up experiment can be an exaggeration of their true outcomes. One method is to move the golf ball 50% closer (false positive feedback) or 50% further (false negative feedback) to the target while preserving the original trajectory. Thus under these conditions, the actual motor activity generated by participants will play a part in trial outcome with participants now having available to them the sensory information generated during the execution of each trial. What will change will be the knowledge of the sensory *consequences* of those motor actions (i.e. positive feedback group participants' original shots will be "helped" toward the target whereas negative feedback participants' shots will be "hindered" by being moved farther away from the target). Thus any external performance feedback provided to participants can now be compared directly to an internally generated, but ultimately irrelevant, motoric representation of action.

There were a few possible explanations as to why the perceptual effect didn't occur under the current experimental manipulations in Experiments 1 and 2. The first was that anxiety can affect perception. Cañal-Bruland, Pijpers, and Oudejans (2010) induced anxiety by having participants complete a dart throwing task either from high on a climbing wall (high anxiety), or from low on a climbing wall (low anxiety). Radial error was negatively correlated with target size perception in the low anxiety condition. There was no correlation when anxiety was high. Thus the experimenters suggested that experiencing high anxiety may interfere with the relationship between performance and perception. In this thesis, two experimenters had to be present to run the equipment and to secretly move the golf balls. The presence of two experimenters observing the participant practicing a novel motor task in a vulnerable state (i.e. no vision and no hearing) may have increased anxiety. Further, because the experiment ended when participants completed a certain number of valid putts, there was also a time pressure that may have contributed to increased anxiety.

Secondly, visual attention played an important role in the action-specific account, as discussed in Section 1.2. Cañal-Bruland et al. (2011) ran a study where participants mini-putted to a golf hole. Over three experiments, they investigated the degree of visual attention that must be focused on the target in order for the action specific effect to occur. They found that full attention to the target was required (versus for instance, dividing their attention by first putting through a gap before the hole). Gray (2015) suggested that when an object was visually attended to, its properties may be accentuated (the attentional accentuation hypothesis). This was one of the possible mechanisms behind the action specific effect. In this thesis, the instructions may have been problematic. Participants were told that the goal was to have the golf ball land in the black circle (i.e. target). However, the requirement of participants to complete a certain number of valid putts combined with the definition of a valid putt being any putts landing within the white concentric circles surrounding the black circle, may have influenced the focus of visual attention. It was possible that participants focused on the largest white circle, which was the minimum requirement to complete the experiment. This may have diminished any action specific effects, or influenced their perception towards other cues rather than the target itself.

Finally, the white concentric circles drawn around the black target circle (please refer to Figure 1) may have created an illusion that contributed to the trend towards overestimation. The Delboeuf Illusion was described as perceiving a circle as larger than it really was in the presence of a larger concentric circle. This was consistent with the data from both experiments in this thesis, where the median diameters of the target size estimations were larger than the actual target size. However, as the Delboeuf Illusion used only one concentric circle, it was uncertain how numerous concentric circles increasing in size affected the perception of the size of the center circle (i.e. the target). While the purpose of the white concentric circles in the present experiment was to allow for more efficient measurement of radial error, using a measuring tape would allow for greater accuracy, and would still be congruent with the cover story (i.e. that this was a learning study, and thus we would be measuring radial error).

One major limitation that when resolved, could potentially alleviate all three issues, would be to conduct the experiment on an open field. This would remove the need for bumpers and the classification of valid or invalid trials. Bringing the experiment out of a closed lab setting could alleviate some of the anxieties of being observed while performing a novel task with unfamiliar people. Further, because there would be no bumpers, invalid trials will no longer exist because all putts can be measured. This would alleviate the time pressure, because instead of the experiment ending after a certain number of valid trials, it would simply end after a number of total trials, regardless of radial error. By combining the open field environment with the use of a measuring tape instead of concentric circles to measure radial error, the goal of the task will become more focused. That is, instead of aiming to land the golf ball within the white concentric circles to accumulate valid trials, participants will only have the golf hole in which to aim. While it does not guarantee full visual attention to the target, the participants' goal, and therefore what they are looking at while they aim, will be more clear. This area of research is valuable to the scientific community. Gray (2015) says that the traditional view of perception was that its goal had been assumed to be providing the brain with an accurate representation of the real world. Studies investigating the action specific effect have shown that this might not be the case (e.g. Bloesch et al., 2012; Cañal-Bruland et al., 2010; Cañal-Bruland et al., 2011; Durgin et al., 2009; Lee et al., 2011; Lewthwaite & Wulf, 2010; Memmert et al., 2009; Riener et al., 2011; Taylor et al., 2011; Witt & Dorsch, 2009; Witt et al., 2008; Witt & Proffitt, 2005). Their findings suggested that various factors can influence how one perceives the world, including recent performance (e.g. Taylor et al., 2011; Witt et al., 2008), mood (e.g. Riener et al., 2011), anxiety (e.g. Cañal-Bruland et al., 2010), current ability (e.g. Durgin, 2009), and contagion (e.g. Lee et al., 2011). The present thesis aimed to contribute to scientific research by investigating whether just the belief in one's performance (whether positive or negative) was sufficient to influence perception. That is, we wanted to investigate whether the action specific effect was due to top-down processes (such that the belief of success may influence perception), rather than to bottom-up processes (such that actual motor performance influences perception). Although our hypotheses were not supported, this series of experiments is still worth conducting again once the limitations are addressed.

More broadly, studies on the action specific effect are applicable to the real-word because they may provide insight on how our perceptions of the world can guide the ways in which we interact with it. For instance, if an athlete is not currently performing well, bottom-up processes may cause him to perceive the target as smaller to encourage better aim. Similarly, if action specific effects are due to top-down processes, coaches can convince an athlete they are not performing well so that they practice aiming to targets that then appear smaller.

6.0 Conclusion

The present thesis was inspired by Witt et al.'s (2008) study that found those who experienced better recent performance perceived target sizes as more favourable (generally, larger target sizes). The series of studies in this thesis have manipulated the type of feedback to help isolate the main influencer behind this effect. When feedback was focused in an external frame so that performance was judged compared to others, there was no influence of performance on perception. Self-reported ratings of task difficulty however, was related to perception. This suggested that it might not be strictly performance that influenced perception, but the subjective opinions of the quality of performance. When visual feedback was instead fully dissociated from true motor action during every trial, there was a positive correlation between performance and perception (i.e. the better they performed (lower radial error), the smaller the target size estimation). It was suspected that visual attention had shifted away from the black target circle and to the concentric white circles. However, some resolvable limitations makes it valuable to repeat these studies under better conditions.

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Appendix A1: Recruitment Poster for Experiment 1

McMaster University

Inspiring Innovation and Discovery

Department of

Kinesiology

Motor Behaviour Laboratory
Ivor Wynne Center, AB131 A-1
1280 Main St. W; Hamilton, ON, L8S 4K1

Get PAID to Mini-Putt!

Task: Golf putting task under degraded sensory feedback.
Minimal personal information will be collected during the study.

Duration: Approx. 1 hr, max of 1:15

Eligibility:

- 18 – 30 years old
- healthy, right-handed
- played golf or mini-putt less than 3 times in the past year (newbies welcome!)

Purpose of the study: To help researchers better understand the influence of degraded sensory feedback (using specialized glasses to block your eye-sight) on the learning of a motor skill (golf putting).

Contact: Afrisa (yeungac@mcmaster.ca) for more information.

This study has been reviewed and cleared by the McMaster Research Ethics Board. If you have concerns or questions about your rights as a participant or about the way the study is conducted, you may contact:

McMaster Research Ethics Board Secretariat
Telephone: (905) 525-9140 ext. 23142
c/o Office of Research Services
E-mail: ethicsoffice@mcmaster.ca

*****Participants will receive $5 for their time. *****
*****and (!!!) chocolate bars (!!!) to snack on!*****

Get PAID to Mini-Putt!
Contact: Afrisa Yeung
yeungac@mcmaster.ca

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Appendix A2: Recruitment Poster for Experiment 2

McMaster University
Inspiring Innovation and Discovery

Department of
Kinesiology

Motor Behaviour Laboratory
Ivor Wynne Center, AB131 A-1
1280 Main St. W; Hamilton, ON, L8S 4K1

Get PAID to Mini-Putt!

Task: Golf putting task under degraded sensory feedback. Minimal personal information will be collected during the study.

Duration: Approx. 1 hr on the first day, 20 min the next day

Eligibility:
- 18 – 30 years old
- healthy, right-handed
- played golf or mini-putt less than 3 times in the past year (newbies welcome!)

Purpose of the study: To help researchers better understand the influence of degraded sensory feedback (using specialized glasses to block your eye-sight) on the learning of a motor skill (golf putting).

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Appendix B1: Consent Forms for Experiment 1

McMaster University
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Department of Kinesiology

1280 Main St. West
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L8S 4K1

Dr. James Lyons
Motor Behaviour Lab
lyonsjl@mcmaster.ca

Winter 2015

Letter of Information and Consent

Title of Study: The influence of degraded sensory feedback on the performance and learning of a golf putting task

Investigators:

James Lyons Ph.D.
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Afrisa Yeung MSc candidate
Department of Kinesiology, McMaster University
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yeungac@mcmaster.ca

Statement of Invitation

You are invited to participate in a research project in the department of Kinesiology at McMaster University. The investigators listed above are conducting this research project. Your involvement and feedback are greatly appreciated and will further our understanding of the factors that influence learning a motor skill under different practice conditions.

Purpose of the Study

The purpose of this study is to examine the effect of degraded sensory feedback on the learning of a motor skill (i.e., golf putting) in young adults. Results from this study will help us to understand the influence of sensory feedback in practice conditions on young adults learning motor tasks.

Procedures involved in the Research

Participation will require approximately 60 minutes of your time. If you agree to participate in this study, you will be asked to complete the following:

1. Provide informed consent prior to the experimental session.
2. Complete a brief demographic questionnaire.
3. Perform the following tasks for data acquisition:

You will be asked to come to the Motor Behaviour Laboratory (IWC AB131 A-1) at McMaster University for one session that will be up to approximately 60 minutes. During this session, you will complete a brief questionnaire and 16 trials of a golf putting task (Block 1). The student researcher will provide clear instructions on what your golf putting task will entail. You will be performing this task under degraded sensory conditions (wearing noise-cancelling headphones and having your vision be temporarily occluded through liquid crystal goggles). Your performance results will be filmed for each trial (birds-eye view of the putting green target). You will not be filmed at any point in the experiment, and the audio will be stripped from the recording. Following completion of the golf putting task, you will be asked to complete a brief computer task.

Following Block 1, you will complete an additional 4 trials (Block 2), again while wearing the headphones and goggles. The experimenter will then provide you your results in a graph format, and then you will move on to Block 3, which is a final 8 trials.

If at any time during the experiment you get tired or feel discomfort, you can take a break, or discontinue your participation.

Potential Benefits and Risks

You will receive $5 for your time, and you will be welcome to snack on the chocolate bars provided. The data obtained will further our understanding of the effect of different practice conditions on motor learning. It is unlikely that you will experience any serious injury or discomfort during the study. There are no serious risks involved in this research. However, if you do experience any concerns, you may contact Dr. Lyons at the above number or email.

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. Further, you may decide to withdraw from this study at any time and may do so without any penalty or loss of benefits to which you are entitled. You will receive $5 at the end of the experiment.

Confidentiality

All information you provide is considered confidential; your name will not be included or, in any other way, associated with the data collected in the study. Furthermore, because our interest is in the average responses of the entire group of participants, you will not be identified individually in any way in written reports of this research. **I will not identify you personally in publications of any form pertaining to this study.** Data collected during this study will be stored in a locked filing cabinet in a locked storage room on campus. Electronic data will be encrypted, stored on an external storage device and locked in the cabinet mentioned above. Access to this data will be restricted to the investigators listed above and their student research assistants.

Contact Information and Ethics Clearance

If you have questions or require more information about the study itself, please contact Dr. James Lyons, Department of Kinesiology, McMaster University, Hamilton, ON, L8S 4K1
(905-525-9140, ext. 27899; lyonsjl@mcmaster.ca).

This study has been reviewed and cleared by the McMaster Research Ethics Board. If you have concerns or questions about your rights as a participant or about the way the study is conducted, you may contact:

McMaster Research Ethics Board Secretariat
Telephone: (905) 525-9140 ext. 23142
c/o Office of Research Services
E-mail: ethicsoffice@mcmaster.ca

Thank you for your assistance in this project. Please keep a copy of this form for your records.

McMaster University
Inspiring Innovation and Discovery

Department of Kinesiology

1280 Main St. West
Hamilton, ON
L8S 4K1

Dr. James Lyons
Motor Behaviour Lab
lyonsjl@mcmaster.ca

Winter 2015

Informed Consent Form

Title of Study: The influence of degraded sensory feedback on the performance and learning of a golf putting task

Investigators:

James Lyons Ph.D.
Department of Kinesiology, McMaster University
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Department of Kinesiology, McMaster University
1280 Main Street West, Hamilton, Ontario, L8S 4K1
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CONSENT

I, ____, agree to voluntarily participate in the study described above.

I have received and read a detailed description of the experimental protocol. I have had the opportunity to ask questions about my involvement in this study and to receive any additional details I wanted to know about the study. I am completely satisfied with the explanation given to me regarding the nature of this research project, including the potential benefits, risks and discomforts related to my participation in this study.

I understand that I have the right to withdraw my consent and discontinue my participation from this study at any time without penalty or prejudices.

___________________________________ ___________________________________

Name of Participant (please print) **Email**

___________________________________ ____________________

Signature of Participant **Date**

In my opinion, the person who has signed above is agreeing to participate in this study voluntarily and understands the nature of the study and the consequences associated with participation.

___________________________________ ____________________

Signature of Researcher or Witness **Date**

Appendix B2: Consent Forms for Experiment 2

McMaster University
Inspiring Innovation and Discovery

Department of Kinesiology

1280 Main St. West
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L8S 4K1

Dr. James Lyons
Motor Behaviour Lab
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Summer 2014

Letter of Information and Consent

Title of Study: The influence of degraded sensory feedback on the performance and learning of a golf putting task

Investigators:

James Lyons Ph.D.
Department of Kinesiology, McMaster University
1280 Main Street West, Hamilton, Ontario, L8S 4K1
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Statement of Invitation

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Purpose of the Study

The purpose of this study is to examine the effect of degraded sensory feedback on the learning of a motor skill (i.e., golf putting) in young adults. Results from this study will help us to understand the influence of sensory feedback in practice conditions on young adults learning motor tasks.

Procedures involved in the Research

Participation will require approximately 60 minutes of your time over two sessions, 24 hours apart. If you agree to participate in this study, you will be asked to complete the following:

1. Provide informed consent prior to the experimental session.
2. Complete a brief demographic questionnaire.
3. Perform the following tasks for data acquisition:

You will be asked to come to the Motor Behaviour Laboratory (IWC AB131 A-1) at McMaster University for one session that will be up to approximately 45 minutes. During this session, you will complete a brief questionnaire and 16 trials of a golf putting task. The student researcher will provide clear instructions on what your golf putting task will entail. You will be performing this task under degraded sensory conditions (wearing noise-cancelling headphones and having your vision be temporarily occluded through liquid crystal goggles). Your performance results will be filmed for each trial (birds-eye view of the putting green target). You will not be filmed at any point in the experiment, and the audio will be stripped from the recording. Following completion of the golf putting task, you will be asked to complete a brief computer task.

Approximately 24 hours later, you will return to the lab to complete 8 additional filmed test trials of the golf putting task, followed by the computer task. If at any time during the experiment you get tired or feel discomfort, you can discontinue your participation.

Potential Benefits and Risks

You will receive $5 at the end of your second session. The data obtained will further our understanding of the effect of different practice conditions on motor learning. It is unlikely that you will experience any serious injury or discomfort during the study. There are no serious risks involved in this research. However, if you do experience any concerns, you may contact Dr. Lyons at the above number or email.

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. Further, you may decide to withdraw from this study at any time and may do so without any penalty or loss of benefits to which you are entitled. You will receive $5 regardless.

Confidentiality

All information you provide is considered confidential; your name will not be included or, in any other way, associated with the data collected in the study. Furthermore, because our interest is in the average responses of the entire group of participants, you will not be identified individually in any way in written reports of this research. **I will not identify you personally in publications of any form pertaining to this study.** Data collected during this study will be stored in a locked filing cabinet in a locked storage room on campus. Electronic data will be encrypted, stored on an external storage device and locked in the cabinet mentioned above. Access to this data will be restricted to the investigators listed above and their student research assistants.

Contact Information and Ethics Clearance

If you have questions or require more information about the study itself, please contact Dr. James Lyons, Department of Kinesiology, McMaster University, Hamilton, ON, L8S 4K1
(905-525-9140, ext. 27899; lyonsjl@mcmaster.ca).

This study has been reviewed and cleared by the McMaster Research Ethics Board. If you have concerns or questions about your rights as a participant or about the way the study is conducted, you may contact:

McMaster Research Ethics Board Secretariat
Telephone: (905) 525-9140 ext. 23142
c/o Office of Research Services
E-mail: ethicsoffice@mcmaster.ca

Thank you for your assistance in this project. Please keep a copy of this form for your records.

McMaster University
Inspiring Innovation and Discovery

Department of Kinesiology

1280 Main St. West
Hamilton, ON
L8S 4K1

Dr. James Lyons
Motor Behaviour Lab
lyonsjl@mcmaster.ca

Summer 2014

Informed Consent Form

Title of Study: The influence of degraded sensory feedback on the performance and learning of a golf putting task

Investigators:

James Lyons Ph.D.
Department of Kinesiology, McMaster University
1280 Main Street West, Hamilton, Ontario, L8S 4K1
(905) 525-9140 ext. 27899
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Kinga Eliasz PhD candidate
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(905) 525-9140 ext. 21436
eliaszkl@mcmaster.ca

Afrisa Yeung MSc candidate
Department of Kinesiology, McMaster University
1280 Main Street West, Hamilton, Ontario, L8S 4K1
yeungac@mcmaster.ca

CONSENT

I, ___________________________, agree to voluntarily participate in the study described above.

I have received and read a detailed description of the experimental protocol. I have had the opportunity to ask questions about my involvement in this study and to receive any additional details I wanted to know about the study. I am completely satisfied with the explanation given to me regarding the nature of this research project, including the potential benefits, risks and discomforts related to my participation in this study.

I understand that I have the right to withdraw my consent and discontinue my participation from this study at any time without penalty or prejudices.

______________________________	______________________________
Name of Participant (please print)	**Email**
______________________________	________________
Signature of Participant	**Date**

In my opinion, the person who has signed above is agreeing to participate in this study voluntarily and understands the nature of the study and the consequences associated with participation.

______________________________	________________
Signature of Researcher or Witness	**Date**

Appendix B3: Post Debrief Implied Consent Form for both Experiments

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Dr. James Lyons
Motor Behaviour Lab
scapps@mcmaster.ca

Summer 2014

Post Debrief Implied Consent Form

Title of Study: The influence of degraded sensory feedback on the performance and learning of a golf putting task

Investigators:
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1280 Main Street West, Hamilton, Ontario, L8S 4K1
yeungac@mcmaster.ca

POST DEBRIEF IMPLIED CONSENT

I have received a detailed written description and explanation of the real purpose of this study. I was informed that having full information about the actual purpose of the study might have invalidated the results. Thus, to ensure that this did not happen, some details misrepresented the real purpose of the study. I have had the opportunity to ask questions about my involvement in this study and to receive any additional details I wanted to know about the study. I am completely satisfied with the explanation given to me regarding the true nature of this research project, including the potential benefits, risks and discomforts related to my participation in this study.

I have been asked to give permission for the researchers to use my data (or information I provided) in their study, and agree to this request. I understand that I have the right to withdraw my consent by notifying the Principal Investigator of this decision to discontinue my participation from this study without penalty or prejudices. I understand that by not contacting the Principal Investigator, the debriefing letter in addition to this consent will serve as implied consent/permission for the study investigators to use my data in their study.

Should I wish to receive my actual performance results and/or a summary (1-2 pages) of the study's results, then I understand I have to contact the following study investigator:
Afrisa Yeung at yeungac@mcmaster.ca

Appendix C: Demographic Questionnaire

Afrisa Yeung, Student Investigator

The following questions ask you to disclose minimal personal information. This personal information is required to be able to report general demographic information about study participants. If you wish, you may decline to answer any questions or participate in any component of the study. All information you provide is considered confidential; your name will not be included or, in any other way, associated with the data collected in the study. Furthermore, because our interest is in the average responses of the entire group of participants, you will not be identified individually in any way in written reports of this research. **I will not identify you personally in publications of any form pertaining to this study.** Data collected during this study will be stored in a locked filing cabinet in a locked storage room on campus. Access to this data will be restricted to the study investigators, Dr. Jim Lyons, PhD student Kinga Eliasz, and myself, Afrisa Yeung.

Participant ID: _______________ Today's Date: ____________________

Age: _______________ **Dominant Hand**: Left / Right

1) **Have you played golf this past year**? Y / N
   If yes, please specify how many times __________________________

   Have you played mini-putt this past year? Y/N
   If yes, please specify how many times __________________________

2) **Have you ever had any golfing experience**?

   If yes, please specify/describe __________________________

3) Do you wear corrective lenses (glasses or contact lenses)? Y / N

   If yes, are you wearing them today? Y / N

   If yes, do you need to wear them when doing a sports task like golf putting? Y / N

4) Do you have any conditions that may prevent you from performing a sports task like golf putting? Y / N
   If yes, please describe ____

5) Using the following scale, please rate on a scale of 0%-100% how **confident** you are that you can successfully learn the golfing putting task and reproduce it at a later time:

   0......10......20......30......40......50......60......70......80......90......100

   I do not feel confident at all — I feel moderately confident — I feel completely confident

6) Using the following scale, please rate on a scale of 0%-100% how **motivated** you are to successfully learn the golfing putting task and reproduce it at a later time:

   0......10......20......30......40......50......60......70......80......90......100

   I do not feel motivated — I feel moderately motivated — I feel completely motivated

<u>Following 16 trials of golf putting:</u>

7) Using the following scale, please rate on a scale of 0%-100% how **confident** you were to successfully learn the golfing putting task and reproduce it at a later time:

0......10......20......30......40......50......60......70......80......90......100

I do not feel confident at all	I feel moderately confident	I feel completely confident

8) Using the following scale, please rate on a scale of 0%-100% how **motivated** you were to successfully learn the golfing putting task and reproduce it at a later time:

0......10......20......30......40......50......60......70......80......90......100

I do not feel motivated	I feel moderately motivated	I feel completely motivated

9) Using the following scale, please rate on a scale of 0%-100% how **difficult** you thought the golf putting task was:

0......10......20......30......40......50......60......70......80......90......100

I did not find it difficult at all	I found it moderately difficult	I found it completely difficult

Appendix D1: Debriefing Letter for Experiment 1

DEBRIEFING LETTER

Department of Kinesiology

1280 Main St. West
Hamilton, ON
L8S 4K1

Dr. James Lyons
Motor Behaviour Lab
lyonsjl@mcmaster.ca

Summer 2014

Title of Study: The influence of degraded sensory feedback on the performance and learning of a golf putting task

Investigators:

James Lyons PhD
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eliaszkl@mcmaster.ca

Afrisa Yeung MSc candidate
Department of Kinesiology, McMaster University
1280 Main Street West, Hamilton, Ontario, L8S 4K1
yeungac@mcmaster.ca

We greatly appreciate your participation in our study, and thank you for spending the time helping us with our research. When you began the study, you were told that the purpose of this study was to examine the effects of degraded sensory feedback on the learning of a motor skill (golf putting) in young adults. Although you were performing the golf putting task under degraded sensory feedback conditions (wearing noise-cancelling headphones and vision occluding goggles), the study was more complicated than we explained at the beginning.

The true purpose of this experiment was to evaluate the influence of perception on performance on a motor skill. In the literature, new findings suggest that the relationship between perception and performance is shared and that action also influences perception. These new findings challenge previous theories that perception occurs independently, through the use of vision and other sensory input. Perception also varies from person to person according to learning and psychological factors like fear, arousal, emotion and other affective states. This becomes problematic when conducting research that involves perception and action. In order to see group effects in this type of research, perception has to be altered, by either positive or negative performance feedback, so that everyone has a similar level of perception. The most successful way to isolate perception and ensure that the behaviour evoked by the performance feedback would be independent of the participants' actual ability or past history is for everyone to receive the same feedback. The only way for us to provide everyone with the same feedback would be to fabricate it.

In this study, you were presented with false performance feedback after a two minute break where you completed some tangram puzzles. Regardless of your actual performance, you were provided with fabricated information about your performance results. Since you were in the ____________ feedback condition, your average score was shown as 20% ____________ than the average of the past 12 participants before you. In the study run just before this present one you participated in, participants' golf balls were moved closer or further from the target. We had them wear noise-cancelling headphones so that they were not able to hear their own golf putt and to ensure that they would believe the false performance results they were being provided after each test trial. Because the study you participated in was a follow up to this previous one, you too, had to wear the noise-cancelling headphones to remain consistent. We want to emphasize to you that the information you received regarding your performance results was fabricated by the researchers.

We could not give participants complete information about the study before their involvement because it may have influenced participants' behaviour during the study in a way that would make investigations of the research question invalid. The reason that we used false performance feedback in this study was because we needed participants' behaviour and attitudes to be unaffected by the study objectives. We apologize for omitting details and for providing you with false information about the purpose of and tasks in our study. We hope that you understand the need for deception now that the purpose of the study has been more fully explained to you. We would also like to assure you that most Psychology and Motor Learning research does not involve the use of deception.

If any of the questions, concerns, comments or exercises in this study caused you to feel uncomfortable, please feel free to contact my faculty supervisor, Dr. James Lyons, anytime at (905) 525-9140 ext. 27899 or email at lyonsjl@mcmaster.ca. Also please feel free to contact McMaster Research Ethics Board Secretariat at (905) 525-9140 ext. 23142 or email at ethicsoffice@mcmaster.ca, if you have any concerns or comments resulting from your participation.

The information you provided will be kept confidential by not associating your name with the responses. The data will be stored with all identifying or potentially identifying information removed. Electronic data will be stored on a password protected computer in the Motor Behaviour Laboratory. Printed data will be kept in a locked room in the Motor Behaviour Laboratory for 5 years following publication and then destroyed by confidential shredding. No one other than the researchers will have access to the data.

Since the study involves some aspects that you were not told about before starting, it is very important that you not discuss your experiences with any other students who potentially could be in this study. If people come into the study knowing about our specific predictions, as you can imagine, it could influence their results, and the data we collect would be not be useable. Also, since we have provided you with this feedback letter, we kindly ask you to please not make this copy available to other students. Moreover, because some elements of the study are different from what was originally explained, we have another consent form for you to read, which will imply consent for us to use the information that you have provided us during the study. This form is a record that the purpose of the study has been explained to you, and that you are willing to allow your information to be included in the study. We really appreciate your participation and hope that this has been an interesting experience.

We thank you again for your valued involvement in this research!

Appendix D2: Debriefing Letter for Experiment 2

DEBRIEFING LETTER

McMaster University
Inspiring Innovation and Discovery

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Dr. James Lyons
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Summer 2014

Title of Study: The influence of degraded sensory feedback on the performance and learning of a golf putting task

Investigators:

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Afrisa Yeung MSc candidate
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1280 Main Street West, Hamilton, Ontario, L8S 4K1
yeungac@mcmaster.ca

We greatly appreciate your participation in our study, and thank you for spending the time helping us with our research. When you began the study, you were told that the purpose of this study was to examine the effects of degraded sensory feedback on the learning of a motor skill (golf putting) in young adults. Although you were performing the golf putting task under degraded sensory feedback conditions (wearing noise-cancelling headphones and vision occluding goggles), the study was more complicated than we explained at the beginning.

The true purpose of this experiment was to evaluate the influence of perception on performance on a motor skill. In the literature, new findings suggest that the relationship between perception and performance is shared and that action also influences perception. These new findings challenge previous theories that perception occurs independently, through the use of vision and other sensory input. Perception also varies from person to person according to learning and psychological factors like fear, arousal, emotion and other affective states. This becomes problematic when conducting research that involves perception and action. In order to see group effects in this type of research, perception has to be altered, by either positive or negative performance feedback, so that everyone has a similar level of perception. The most successful way to isolate perception and ensure that the behaviour evoked by the performance feedback would be independent of the participants' actual ability or past history is for everyone to receive the same feedback. The only way for us to provide everyone with the same feedback would be to fabricate it.

In this study, you were presented with false performance feedback following each golf putting test trial during session 1. After you successfully completed the golf putting trial (putting the ball within the concentric circles), regardless of your actual performance, you were provided with fabricated information about your performance results. Since you were in the ____________ feedback condition, your golf ball was moved ___________ the golf hole when the goggles temporarily blocked your vision. You were also required to wear the noise-cancelling headphones so that you were not able to hear your own golf putt and to ensure that you would believe the false performance results you were being provided after each test trial. By doing this, we tried to influence your perception of how well you performed on the golf putting task in order to investigate whether this would have an effect on how you learned this motor task (golf putting). We want to emphasize to you that the information you received regarding your performance results was fabricated by the researchers and we in fact have not even analyzed any participant data at this present time and do not even have this information to give to you.

We could not give participants complete information about the study before their involvement because it may have influenced participants' behaviour during the study in a way that would make investigations of the research question invalid. The reason that we used false performance feedback in this study was because we needed participants' behaviour and attitudes to be unaffected by the study objectives. We apologize for omitting details and for providing you with false information about the purpose of and tasks in our study. We hope that you understand the need for deception now that the purpose of the study has been more fully explained to you. We would also like to assure you that most Psychology and Motor Learning research does not involve the use of deception.

If any of the questions, concerns, comments or exercises in this study caused you to feel uncomfortable, please feel free to contact my faculty supervisor, Dr. James Lyons, anytime at (905) 525-9140 ext. 27899 or email at lyonsjl@mcmaster.ca. Also please feel free to contact McMaster Research Ethics Board Secretariat at (905) 525-9140 ext. 23142 or email at ethicsoffice@mcmaster.ca, if you have any concerns or comments resulting from your participation.

The information you provided will be kept confidential by not associating your name with the responses. The data will be stored with all identifying or potentially identifying information removed. Electronic data will be stored on a password protected computer in the Motor Behaviour Laboratory. Printed data will be kept in a locked room in the Motor Behaviour Laboratory for 5 years following publication and then destroyed by confidential shredding. No one other than the researchers will have access to the data.

Since the study involves some aspects that you were not told about before starting, it is very important that you not discuss your experiences with any other students who potentially could be in this study until after the end of the term. If people come into the study knowing about our specific predictions, as you can imagine, it could influence their results, and the data we collect would be not be useable. Also, since we have provided you with this feedback letter, we kindly ask you to please not make this copy available to other students. Moreover, because some elements of the study are different from what was originally explained, we have another consent form for you to read, which will imply consent for us to use the information that you have provided us during the study. This form is a record that the purpose of the study has been explained to you, and that you are willing to allow your information to be included in the study. We really appreciate your participation and hope that this has been an interesting experience.

We thank you again for your valued involvement in this research!