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The Effects of Focus of Attention on Visual Skill Performance in a Patient Poulation

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THE EFFECTS OF FOCUS OF ATTENTION ON VISUAL SKILL PERFORMANCE IN A PATIENT POPULATION

by

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Introduction

What an individual chooses to direct their attention toward while performing a motor skill may greatly affect their performance. If an individual focuses on the movement effects it is considered an external focus. However, when an individual focuses on the movements of their body or movement pattern the focus is considered to be internally directed (Wulf & Prinz, 2001). For instance, a jogger focusing on the sole of his or her *shoe* pushing off the pavement would be considered an external focus of attention because the runner is concentrating on the result of the movement. Alternatively, if that same jogger were to focus on pushing off the pavement with his or her *feet* the focus of attention would be internal because the runner is now directing attentional resources towards the movements of their feet. Previous studies have consistently reported when individuals focus on the movement outcome (i.e., external focus) their performance levels are enhanced relative to when they focus on the movement pattern (i.e., internal focus) (for a recent review see Wulf, 2012).

A study conducted by Wulf, McNevin, and Shea (2001) was one of the first studies to test the predictions of the “constrained action hypothesis.” This hypothesis proposed a plausible explanation for the advantages of an external focus of attention compared to an internal focus of attention. The constrained action hypothesis proposes that using an internal focus of attention causes the individual to consciously concentrate on controlling their movements, thus limiting their ability to perform the task non-consciously or at an autonomous level of neuromotor control. In contrast, using an external focus allows the individual to direct their attention distally from their body, making available more degrees of freedom and promoting a more automated method of movement (Wulf, McNevin et al., 2001; Zachry, Wulf, Mercer, & Bezodis, 2005).

Wulf, McNevin et al. (2001) tested the predictions of the constrained action hypothesis by using a secondary probe reaction time task to compare the attentional demands of internal and external focus conditions. The primary task in that study was to maintain balance on a stabilometer, more specifically the task was to keep the platform in the horizontal position for as long as possible during each of the trials lasting 90 seconds. The secondary task was to respond to an auditory stimulus as fast as possible using a hand-held trigger. Participants were assigned to either an internal or external focus condition. Participants in the internal focus condition were instructed to focus on their feet; in the external focus condition participants were instructed to focus on markers that were placed 22 cm in front of their feet. The auditory stimuli took place a total of eight times at random intervals during six of the seven practice trials.

Dual-task methods provide a means to determine the attentional demands placed upon individuals (Wright & Kemp, 1992; Wulf, McNevin et al., 2001). More specifically, if an individual performs poorly on a secondary reaction time task, one can then conclude that the primary task required the majority of the individual's attention. Conversely, if the individual performs well on the secondary task one can infer that the primary task did not require an abundance of the person's attention, thus allowing them to allocate more of their attentional resources to performing the secondary task. The results of the Wulf, McNevin et al. (2001) study demonstrated that individuals who were instructed to adopt an external focus exhibited better performance on the primary task (i.e., balancing on a stabilometer), and also had a faster reaction time on the secondary task (i.e., auditory stimuli) than the individuals who were instructed to direct their attention internally. These results supported the predictions of the constrained action hypothesis by indicating that the external focus condition allowed for more efficient automated movements and permitted the individual to direct more of their attention to the secondary task in comparison to trials completed in the internal focus condition. Wide arrays of motor skills have been utilized to test the attentional focus effects. Ranging from: balancing on a stabilometer (Shea & Wulf, 1999), golf shot (Wulf & Su, 2007), standing long jump (Porter, Anton, & Wu, 2011) and basketball free throws (Zachry et al., 2005). In each of these studies motor behavior was superior when participants directed their attention externally, rather than internally. Research has indicated that not only does utilizing an external focus improve movement outcome, it also shows a reduction in electromyography (EMG) activity. EMG allows researchers to study muscular activity by examining electrical signals emitted during muscle contractions (Acierno, Baratta, & Rouge, 1995). Surface EMG data is collected by electrodes that have been placed upon an individual's skin over the muscle(s) intended for analysis. One study in particular showed that adopting an external focus of attention increased basketball free throw accuracy while at the same time lowering EMG activity of the participant's biceps and triceps muscles (Zachry et al., 2005). In that study participants performed the task under both internal and external focus conditions. The instruction for adopting an internal focus was to concentrate on the "snapping" motion of the wrist; while instructions for implementing an external focus indicated that the participant should focus on the "center of the rear of the basketball hoop." The authors concluded that the improved performance accompanied by a reduction of neuromuscular activity suggests that utilizing an external focus induces greater movement economy. Therefore, directing one's attention internally increased impulses in the motor system (i.e., increased muscle activation), which consequently constrained the individual's automatic or unconscious control processes. The authors noted that the lack of significant difference between the agonist muscles (i.e., flexor carpi radialis and deltoid) activation was observed between conditions; only the antagonist muscles (i.e. biceps and triceps) showed significant differences in EMG activity. This finding suggests that an external focus of attention may enhance coordination between the agonist and antagonist muscle groups. The increased co-contraction of the antagonist muscle group accompanied with an internal focus of attention indicates that movement efficiency is decreased because motor units are recruiting more muscle fibers than may be necessary to perform the task. Overall, the lower EMG activity associated with an external focus suggests that movement is made more efficiently when compared to using an internal focus.

Employing an external focus of attention has been shown to increase jump height while reducing EMG activity (Wulf, Dufek, Lozano, & Pettigrew, 2010). This study asked participants to perform a vertical jump-and-reach test. Participants performed ten jumping trials under both external and internal conditions. Significant differences in EMG activity were found between the internal and external groups. Generally, when participants adopted an external focus, EMG activity was lower than when an internal focus was utilized. The decreased muscle activation accompanied by increased jump height associated with an external focus of attention implies greater coordination within muscles and limbs. The authors noted that enhanced movement efficiency is normally seen in advanced stages of learning. This suggests that employing an external focus of attention may possibly accelerate the learning process.

Marchant, Greig, and Scott (2009) examined the influence of attentional focus instructions on muscular activity and force production in isokinetic elbow flexions. For this study participants first completed ten repetitions of isokinetic maximum voluntary contractions of the elbow flexors of the dominate arm without verbal instructions directing their attention (i.e., control condition). While in the internal condition the attention of the individuals were directed towards focusing on their arms and muscles during the lift. However, in the external condition, attention was directed towards focusing on the movement of the crank hand bar during the lift. This study found that verbally instructing the individuals focus externally resulted in significantly greater force production and lower EMG readings compared to the internal focus condition. These results exhibit that instructions aimed to elicit an external focus of attention not only aid the performance of skill execution (e.g., Wu, Porter, & Brown, 2012; Wulf & Su, 2007; Wulf et al., 2010; Zachery et al., 2005) but also assist with tasks involving force production. The lower EMG activity associated with the external condition indicates that both coordination and recruitment of the muscles are accomplished more efficiently relative to trials completed while attention is directed externally. The authors (Marchant et al., 2009) noted that the reduced force production that was observed while directing attention internally may be related to inefficient muscular activation. Moreover, in the internal condition individuals may have been consciously controlling their movement which may have hindered their ability to optimally coordinate muscles and produce greater force.

Additional research has been conducted to determine the generalizabilty of focus of attention effects on individuals with disabilities. The positive effects of an external focus of attention have been observed in children with intellectual disabilities (Chiviacowsky, Wulf, & Avila, 2012) and in children with Attention-deficit/hyperactivity disorder (Saemi, Porter, Wulf, Ghotbi–Varzaneh, & Bakhtiari, in press). One study conducted in 2009 by Wulf et al., found that implementing an external focus of attention reduced postural instability in individuals with Parkinson Disease (PD). In that study participants were asked to balance on an inflated rubber disk. The procedure required the individuals to perform four trials for 15-seconds in each of three conditions: control, internal, and external. The control condition instructions were simply to "stand still." The internal condition instructions were "focus on minimizing the movements of your feet." Lastly, the external condition instructions were "focus on minimizing the movements of the disk." In order to prevent carryover effects, the order of conditions were counterbalanced. The results showed that participants enhanced their balance when instructions directed their attention externally compared with both internal and control instructions. No significant difference was observed between the control and internal conditions. These results indicate that providing instructions that direct attention internally may yield the same results as providing neutral instructions (not aimed to induce a specific focus) as was the case in the control condition. This research builds support for clinicians working with individuals who are diagnosed with PD to employ instructions that direct the client's focus of attention externally. The results of this study further suggest that if clinicians were to implement instructions that generated an external focus of attention (e.g., directing focus away from body movements) the individual may exhibit enhanced postural stability. This is a meaningful finding considering previous research has shown that increased postural instability leads to an increased risk for falling among individuals with PD (Mantinolli, Korpelainen, Korpelainen et al., 2009).

Fasoli, Trombly, Tickle-Degnen, and Verfaellie (2002) conducted a study on the effects that instructions have on individuals with and without cerebrovascular accident (CVA) (i.e., stroke). They asked participants to perform three specific tasks: remove a can from a shelf, put an apple into a basket, and move a coffee mug onto a saucer. The researchers found that with all three tasks, an external focus led to greater peak velocity and sizably faster movement times. Again, these findings of enhanced performances provide validity for professionals to employ instructions that result in focus of attention being directed externally.

"Chemo-brain" or "chemo-fog" is described as difficulties with memory, focus, attention, reduced motor functioning and difficulty executing motor skills that involve visual accuracy and tracking (Porter & Anton, 2011; Staat & Segatore, 2005). The American Cancer Society predicted that a total of 1,660,290 new cancer cases would be diagnosed in 2013. The percentage of those surviving cancer is increasing and can be attributed to advancements in diagnosis and treatments (American Cancer Society, 2013). The 5-year survival rate of those diagnosed between 2002 and 2008 increased to 68%, up from 49% in 1975-1977 (American Cancer Society, 2013). As cancer targeted therapies improve survival ratings, side effects of such therapies are becoming more prevalent. In 2011 a study conducted by Porter and Anton sought to determine whether verbal instructions aimed to manipulate focus of attention influenced the execution of a continuous visuomotor tracking task in older adults who had previously undergone chemotherapy. A total of five participants performed three 30 second trials of a novel photoelectric rotary pursuit tracking task in each of the following conditions: internal, external and control. The visuomotor task required participants to track a rotating light using a handheld stylus. The researchers measured the total time the stylus was in contact with the light. In the control condition the participants were instructed to “Track the rotating light to the best of your ability.” In the internal condition participants were instructed “While you are tracking the rotating light, focus on moving your hand at the same speed of the rotating light.” Lastly, in the external condition participants were instructed “While you are tracking the rotating light, focus on moving the handle of the stylus at the same speed as the rotating light.” The results indicated that instructions that induced an external focus yielded superior performance results in comparison to both internal and control conditions. Specifically, the verbal instructions that induced an external focus of attention yielded performance benefits for older adults who had previously undergone cancer chemotherapy and were suffering from symptoms of “chemo-brain.”

No additional research has been conducted to further investigate the existence of a relationship between motor performance and focus of attention in individuals who have had cancer or have undergone cancer chemotherapy. Furthermore, a limitation of the research conducted by Porter and Anton (2011) was that they did not take into consideration muscular activation. As discussed above, previous research has demonstrated that an external focus of attention results in lower muscle activation which signifies greater movement efficiency (Marchant et al., 2009; Wulf et al., 2010).

Considering there is an increasing number of individuals who are diagnosed with cancer and undergoing chemotherapy treatment, more research in this area is warranted. Thus, the purpose of the present study was to further investigate focus of attention effects on continuous visuomotor skill performance in individuals who currently have cancer or has had cancer. The current study employed a similar methodology to the study conducted by Porter and Anton (2011), with the addition of recording surface EMG in order to analyze both motor performance and movement efficiency. Based upon previous research, it was hypothesized that instructions which directed one's attention externally would result in better motor performance (i.e., increased time on target) and increased movement efficiency (i.e., decreased muscle activation) than instructions directed to induce one's attention internally or neutrally (control condition). Also, it was hypothesized that no significant differences would be observed between the time on target and EMG activity of the internal focus condition and the neutral condition.

Method

Participants

A total of 13 individuals who currently have cancer or has had cancer (n = 10 females; n = 3 males, *M*age = 62.9 years, *SD* = 8.94) participated in the present study. Eight of the 13 participants had previously undergone chemotherapy treatment. Participants were recruited via a local cancer rehabilitation program. The Human Subjects Committee at Southern Illinois University Carbondale approved the materials and methodology employed in the present study. Each participant was required to give an informed consent prior to beginning data collection.

Apparatus and task

Participants in this experiment were standing while performing the rotary pursuit task. The rotary pursuit device was placed on a portable cart in front of the participant at approximate waist height. Books were placed beneath the device to increase the height as needed. The rotary pursuit device consists of a 2.54 by 2.54 cm florescent light which rotated in a clockwise circular pattern underneath a clear glass panel parallel to the desktop. The participant held a stylus containing a light sensitive photocell at the tip of the instrument. Each participant was asked to take the hand-held stylus with their dominant hand and track the rotating light following three different verbal instructions described below.

Prior to beginning the first trial surface electrodes were placed on the participant's skin directly over their anterior and posterior deltoids in order to record the muscle activity of the dominate shoulder. When the photocell at the end of the stylus was in contact with the rotating light, the clock attached to the rotary pursuit device measured the amount of time the photocell and rotating florescent light were in contact. The dependent variables were the total contact time for each 30 second trial (i.e., time on target) and the amount of muscle activation recorded by the EMG electrodes. The Lafayette Instrument Company's Rotary Pursuit Model 30014A was utilized to measure the total contact time for all trials. Qualisys Track Manager Motion Capture System (version 2.4) software was used to measure muscle activation with a sampling rate of 1000Hz for each 30-second trial. The surface electrodes placed on the anterior and posterior deltoids were Biopac Systems Incorporated EL504 2.54 cm square cloth solid gel electrodes.

Procedures

Upon arrival at the laboratory, participants were given an informed consent to review and sign. After receiving informed consent the participants were given a brief overview of the task and apparatuses. Participants were informed that the action was a visual tracking task in which they were to track the revolving light to the best of their ability using a handheld light-sensitive stylus. Next, the surface electrodes were placed on the participant's anterior and posterior deltoids. Using a counterbalanced within-participant design, the participants performed the task in three experimental conditions (i.e., control, internal, external). Participants were given the following instructions while in the Control condition, "track the rotating light to the best of your ability." When the subjects were in the Internal condition they were instructed "While you are tracking the rotating light, focus on moving your hand at the same speed as the rotating light." In the External condition participants were instructed "While tacking the rotating light, focus on moving the handle of the stylus at the same speed as the rotating light." Participants performed five 30 second trials per condition for a total of 15 trials. Participants were provided a 1 minute rest between trials.

Data Analysis

For each 30-second trial the amount of time that the light-sensitive stylus was in contact with the rotating light (i.e., time on target) was recorded and served as one of the dependent measures. A mean time on target was calculated for each participant in all conditions. Time on target data were analyzed using a univariate repeated measures analysis of variance (ANOVA). The two surface electrodes placed upon each participant's dominant shoulder profiled the muscle activation levels throughout each 30-second trial. These data served as the second and third dependent measures in the analysis. The EMG measures for every participant within all conditions were averaged. The muscle activity data were then analyzed by using separate univariate repeated measures ANOVAs. Statistical analyses were performed using the SPSS version 19.

Results

Time on Target

The results of the ANOVA indicated a significant main effect, $F(2, 128) = 13.003$ $p = 0.001$. A least significant difference (LSD) *post-hoc* test was conducted to further investigate the observed main effect. The *post-hoc* analysis revealed that the Control and External conditions were significantly different than the Internal conditions. No significant differences were found between the External and Control conditions. The average times on target for the each condition are displayed in Figure 1.

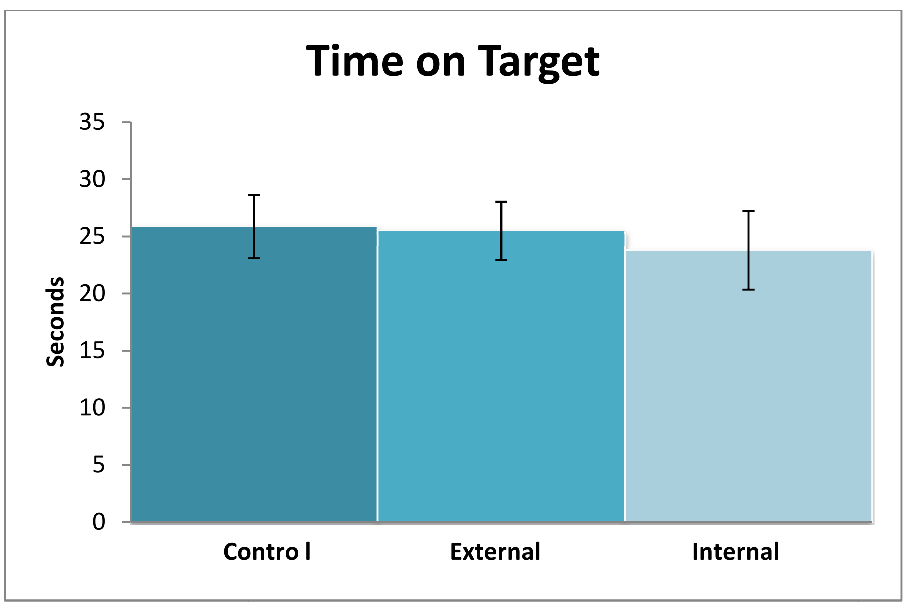

Figure 1. Average time on target for Control, External and Internal focus of attention conditions; the error bars represent standard deviation.

Anterior Deltoid Muscle Activity

The results of the ANOVA indicated that there was not a main effect between the three conditions, $F(2, 118) = 1.779$, $p = 0.173$. The average muscular activity for all three conditions is depicted in Figure 2.

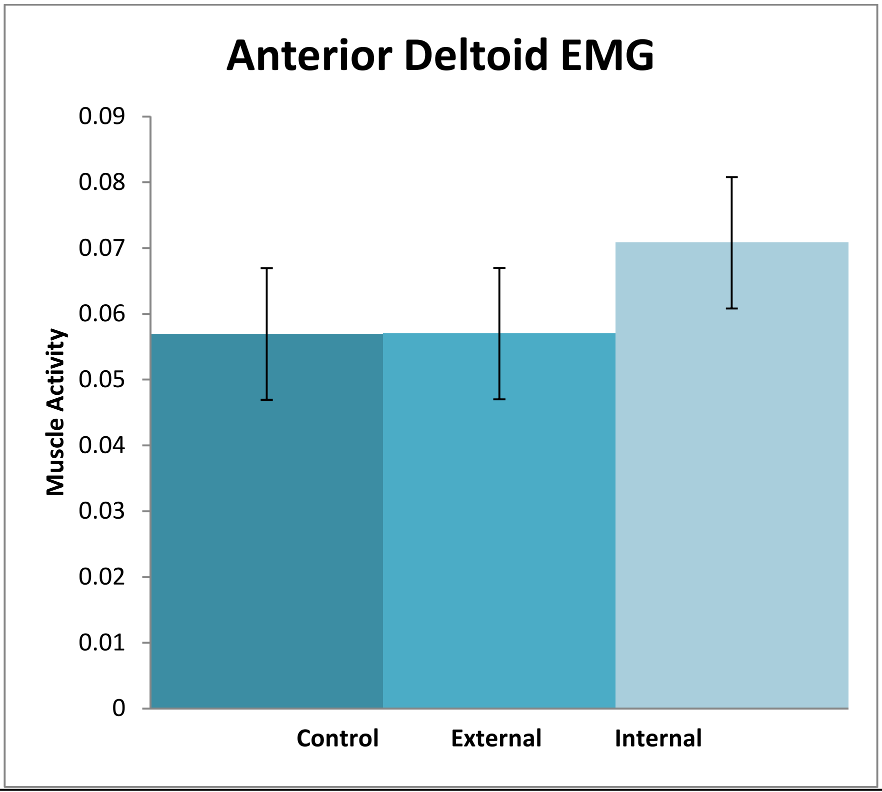

Figure 2. Average anterior deltoid muscle activity for Control, External and Internal focus of attention conditions; the error bars represent standard deviation.

Posterior Deltoid Muscle Activity

The results of the ANOVA analyzing the posterior muscle activity indicated that there was a significant main effect, $F(2, 118) = 4.074$, $p = 0.019$. The *post-hoc* analysis revealed that the Control condition was significantly different than the Internal and External conditions. No significant differences were found between the External and

Internal conditions. Averages of the posterior deltoid muscle activity are displayed in Figure 3.

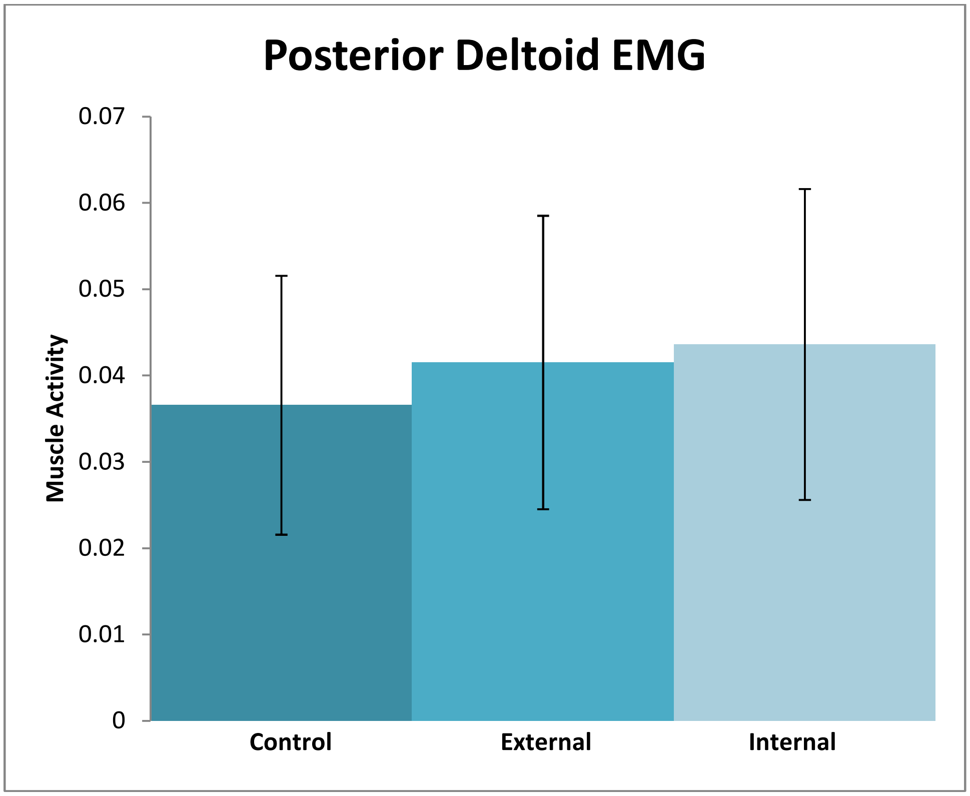

Figure 3. Average posterior deltoid muscle activity for Control, External and Internal focus of attention conditions; the error bars represent standard deviation.

Discussion

The purpose of the present study was to investigate focus of attention effects on continuous visuomotor skill performance in individuals who currently have cancer or have had cancer. Based upon previous research, it was hypothesized that instructions which directed one's attention externally would result in better motor performance (i.e., increased time on target) and increased movement efficiency (i.e., decreased EMG) than instructions directed to aim one's attention internally or neutrally. It was also hypothesized that no significant differences would be observed between the time on target and EMG activity of the internal focus condition and the control condition.

As hypothesized, externally directed focus of attention instructions resulted in increased time on target in comparison to internally directed instructions. These results are in concurrence with the constrained action hypothesis which states that using an internal focus of attention causes the individual to consciously concentrate on controlling their movements which limits their ability to perform the task at an autonomous level of neuromotor control. Contrary to the experimental hypothesis, the ANOVA results indicated that there were no significant differences between time on target in the External and Control conditions. Moreover, participants time on target, while in the Control condition, were superior to trials in the Internal condition. This finding suggests that utilizing an internal focus of attention did indeed hinder the participants ability to perform the manual tracking task. However, this finding also implies that adopting an external focus of attention did not enhance one’s natural ability to perform the visual tracking task; if it had, then the External condition should have been superior to the Control condition.

In a recent study conducted by Makaruk, Porter, Dlugolecka, Parnicka, and Makaruk (in press), the authors examined attentional focus effects on muscular power in older women. Similar to the findings reported in the present experiment, the results of that study indicated that the external and control focus conditions were not significantly different, and both were superior to the internal focus condition. In that study the researchers utilized a cycle ergometer (i.e., Wingate) test. They concluded that the stable position and isolated movements of the ergometer limited the number of degrees of freedom and motor control constraints. As a result the external condition did not display gains in muscular power relative to trials completed in the control condition. Perhaps this concept could be used to explain the findings in the present research; the constant position and repeated isolated movement pattern of the rotary pursuit tracking task may have limited the number of degrees of freedom and motor constraints. Meaning the task was not mechanically complex enough for external focus instructions to be advantageous over what the participants freely chose to focus on during the Control condition.

Another plausible explanation for the lack of observable differences between the External and Control conditions is that the visuomotor tracking task itself may have not yielded the level of task difficulty needed to elicit benefits from utilizing an external focus of attention. A study conducted by Wulf, Tollner, and Shea (2007) examined if the advantages of adopting an external focus of attention were only observed for more challenging tasks compared to less challenging tasks. To research this concept these authors utilized balance tasks that became increasingly more challenging to maintain stability. The results of the Wulf et al. (2007) study indicated that the attentional focus effects only existed when the support surface sufficiently compromised the participant's ability to maintain balance. The results of this study support the concept that a certain degree of task difficulty maybe a requirement for attentional focus effects to take place. The time on target averages and standard deviations of the present research (i.e., Control = 25.9 ± 2.8 sec; External = 25.5 ± 2.6; Internal = 23.8 ± 3.5) are much higher in comparison to the results reported by Porter and Anton (2011) (i.e. Control; 15.1 ± 3.6, External; 20.8 ± 4.8, Internal; 17.4 ± 3.4). The elevated time on target data in the current study with the same task as that employed by Porter and Anton (2011) suggests that the task may not have been as challenging for participants in the present study. Considering that the present study mirrored the task and population used in Porter and Anton (2011) study one would expect to find similar averages and standard deviations in time on target data. However one key distinction between the volunteers used in the present study and those used by Porter and Anton (2011) was the compromised state of their cognitive system. All of the participants in the Porter and Anton (2011) study had cognitive deficits as a result of suffering from "chemo-brain." By point of comparison, the participants in the present study did not overly display cognitive deficits or suffer from symptoms consistent with chemo-brain. From this comparison it may be concluded that the task did not reach the degree of difficulty needed to bring about attentional focus effect in the sampled population used in the current experiment. Additional research is needed to fully test this speculation.

Above we have shown that an internal focus of attention does hinder motor performance however, no significant differences in the muscular activation of the anterior deltoid were observed. As with the time on target data, perhaps the same could be assumed for the anterior deltoid muscle activity. That is, from a mechanical standpoint the visuomotor tracking task may not have been a difficult enough movement pattern to elicit measurably beneficial attentional focus effects. However, the analysis of the muscular activation of the posterior deltoid indicated there were meaningful group differences; the muscle activation levels of participants were significantly lower in the Control condition in comparison to the External and Internal focus conditions which were not significantly different from each other. This result suggests that the Control condition elicited greater movement efficiency than both the External and Internal focus conditions. By and large, research has shown that adopting an external focus of attention yields superior results, and utilizing an internal or neutral focus of attention generally results in a less efficient movement production (Marchant et al., 2009; Wulf et al., 2009). However, in 2008 Wulf researched attentional focus effects in elite acrobats, the purpose was to examine if the benefits of using external focusing instructions generalized to top-level performers. The task required participants to balance on an inflated rubber disk. In the control condition participants were asked to “stand still.” For the external focus condition participants were asked to “focus on minimizing movements of the disk.” Lastly, the internal focus instructions were “focus on minimizing movements of your feet.” Mean power frequencies (MPF) scores were analyzed to compare conditions. The results of the analysis indicated that MPF’s were significantly higher in the control condition than in the internal or external focus conditions. The authors noted that a higher response frequency is a characteristic of increases in the number of active degrees of freedom and signifies a greater level of automaticity, indicating a more effective motor behavior. Wulf (2008) concluded that asking the participants to focus on movements of the disk was not beneficial for performance because it degraded the acrobats well-learned movement dynamics. Wulf stated that when the expert acrobats were able to freely choose where to direct their focus they were able to compensate for disturbances more effectively. This resulted in the higher MPF’s observed in the control condition. Wulf also noted that movement details may serve to disrupt the automatic control process that the expert has developed. And trying to consciously control the movement may have led to a regression of earlier learned strategies, causing movements that were normally performed effectively to be disrupted. In the present research the mechanical simplicity of the visuomotor task and the isolated movement pattern allowed participants to perform the task too easily. Therefore, when participants were instructed to concentrate on their hand (i.e., internal focus) or the handle (i.e., external focus) the participants began to concentrate on controlling their movements or the movement effects, thus limiting their ability to perform the task non-consciously which diminished the movement efficiency. As a result, increases in muscular activation were observed in the analysis of the posterior deltoid in the External and Internal conditions relative to trials completed in the Control condition.

Limitations and Future Directions

Although the results of this study contribute to the existing body of research on focus of attention, there are limitations to this experiment which offer avenues for future experimentation. For example, this research did not take into consideration the type or stage of cancer within the sampled population. Furthermore, no treatment history outside of chemotherapy was assessed. Future studies should evaluate the type, treatment, and stages of cancer in patients. Being able to classify participants through similarities in diagnosis, treatment history and type of cancer may provide valuable insight on focus of attention effects for different types of cancer and the effects of focus of attention in different treatment modalities.

Additionally, task difficulty should be assessed and dependent upon the abilities of the group to ensure the task will meet the level of difficulty needed to elicit possible attentional focus effects. Conducting ample pilot testing trials of a task would help to determine the level of task difficulty. Future studies should try to increase mechanical complexity of the task to ensure the task is complex enough to elicit focus of attention effects in muscular activity. Additionally, future studies should consider collecting qualitative data in the Control condition; such as a one-item questionnaire asking participants to report what they chose to focus on during the Control condition when no specific instructions are given. This data could provide valuable insight on what individuals choose to focus on when left to their own autonomy.

General Conclusion

The present research adds to a growing body of research that demonstrates utilizing an internal focus of attention negatively influences an individual's ability to manually track an object. With an increasing number of individuals who are diagnosed with cancer and as cancer targeted therapies improve survival ratings, side effects of such therapies are becoming more prevalent (e.g., chemo-brain). For this reason it is important for cancer rehabilitation health professionals to avoid using verbal instructions that direct one's attention to the movement pattern (i.e., internal focus). Future studies to investigate focus of attention effects are necessary to determine what type of focus is most beneficial for cancer patients.

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