

INCREASED MOVEMENT ACCURACY AND REDUCED EMG ACTIVITY AS THE RESULT OF ADOPTING AN EXTERNAL FOCUS OF ATTENTION

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The performer's focus of attention has been shown to play an important role in the performance and learning of motor skills. Specifically, focusing on one's body movements (i.e., adopting an *internal* focus) during the execution of a motor skill has been found to be relatively ineffective; in contrast, giving instructions or feedback that direct the performers' attention to the effects that their movements have on the environment, such as the apparatus or implement (i.e., adopting an *external* focus), has been demonstrated to result in more effective learning than inducing an internal focus or giving no specific focus instructions (e.g., Shea & Wulf, 1999; Wulf, McConnel, Gärtner, & Schwarz, 2002; Wulf, Höß, & Prinz, 1998; Wulf, Shea & Park, 2001; Wulf, Weigelt, Poulter, & McNevin, 2003; for a review, see Wulf & Prinz, 2001).

Previous studies examining the effects of internal versus external foci of attention have exclusively used *outcome* measures (Magill, 2001; Schmidt & Lee, 1999) to assess performance and learning. In the present study, we therefore wanted to examine whether performance differences under external versus internal focus conditions would also be observed at a neuromuscular level. Specifically, we used electromyography (EMG) to measure the electrical activity associated with muscle contractions under internal versus external focus conditions. Performance *production* measures (Magill, 2001) such as EMG might provide more insight into how the nervous system operates to produce attentional focus effects. If, as proposed by the constrained action hypothesis (e.g., Wulf, McNevin, & Shea, 2001), an external focus results in a more automatic type of control than an internal focus, one might expect to see differences in EMG activity under external relative to internal focus conditions.

In a within-subject design, participants were required to perform basketball free throws while focusing either on their wrist motion (internal focus) or the basket (external focus). EMG activity was recorded for various muscle groups of the shooting arm (m. deltoid, m. biceps brachii, m. triceps brachii, m. flexor carpi radialis). If a greater throwing accuracy under the external relative to the internal focus condition, if any, were accompanied by decreased EMG activity, this would provide more direct evidence for the view that performance benefits of an external focus are due to the utilization of more effective and efficient motor control processes.

Results

Free throw accuracy. When participants were instructed to adopt an external focus their accuracy was higher compared to when they adopted an internal focus (see Figure 1). The average accuracy score was 2.56 for the external focus condition and 2.09 for the internal focus condition.

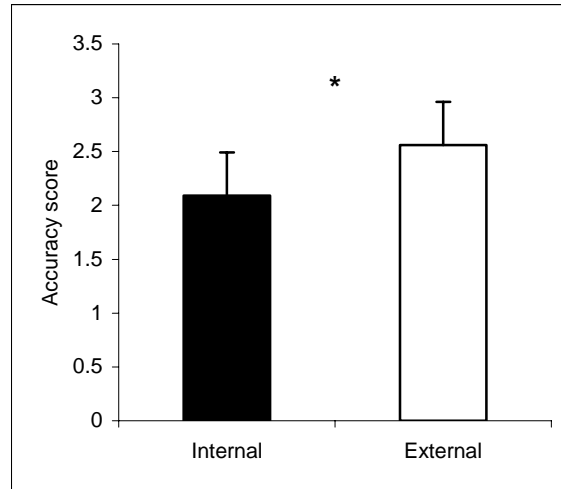


Figure 1

EMG. Average EMG activity for flexor carpi radialis (FCR), biceps brachii (BB), triceps brachii (TB), and deltoid (D) is shown in Figure 2. Muscular activity was significantly lower under the external relative to the internal focus condition for BB and TB.

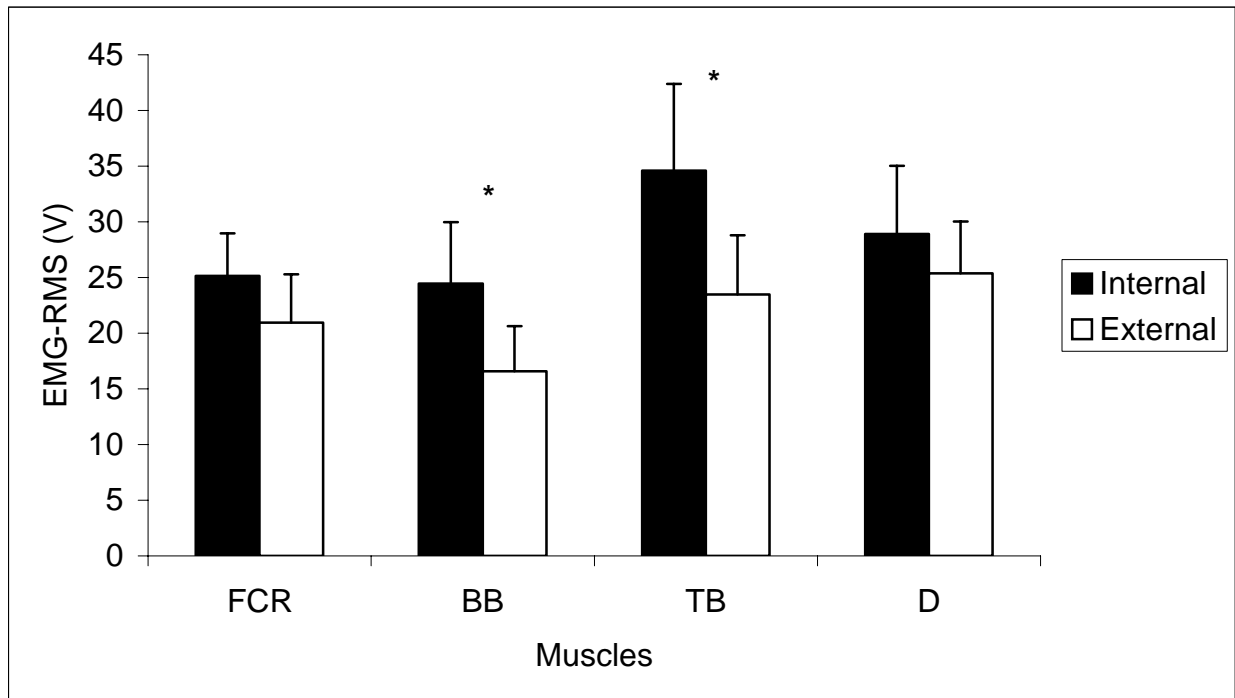


Figure 2

Discussion

The present results confirm and extend previous findings. First, the greater movement accuracy (i.e., higher scores) in free throw shooting seen under the external relative to the internal focus condition is in line with previous studies showing external focus advantages in movement outcome (for a review, see Wulf & Prinz, 2001). Many of those previous studies used learning designs, where different groups of participants practiced a task under either internal or external focus conditions (or control conditions), and where learning was assessed in retention or transfer tests. In contrast, the present study used a within-participant design, in which all participants performed under both internal and external focus conditions. The fact that attentional focus effects occur not only in learning studies, but even when within-participant designs are used, suggests that the type of focus has relatively strong and immediate effect on performance.

Importantly, the greater movement accuracy seen under the external focus condition was accompanied by reduced EMG activity in the shooting arm, compared to the internal focus condition. Even though there was no significant attentional focus difference in EMG activity for flexor carpi radialis or deltoid, biceps and triceps activities were significantly lower when participants focused externally. This reduced EMG activity when participants adopted an external focus might be viewed as reflecting a greater economy in movement production. Adopting an internal focus (wrist motion), on the other hand, presumably acted to constrain the motor system and led to a “freezing” of the neuromuscular degrees of freedom.

Interestingly, attentional focus differences in EMG occurred in muscle groups that participants were not specifically instructed to focus on. This suggests that the effects of attentional focus on the motor system are rather general in nature, in that they “spread” to muscle groups that are not in the performer’s focus of attention. It appears that the focus on a certain part of the body (e.g., hand) not only has an influence on the control of its movement, but on the control of other parts of the motor system as well. In other words, an internal focus appears to constrain not only the action of the body part that the individual focuses on, but also the action of other parts – and perhaps even the whole motor system.

The reduced EMG activity observed under the external focus condition was accompanied by greater movement accuracy (i.e., free throw accuracy), compared to the internal focus condition. Presumably, the increased noise in the motor system (i.e., increased EMG activity) that resulted from the internal focus hampered fine movement control and made the outcome less reliable. This suggests that focusing one’s attention on the movement effect (external focus), rather than on the movements required to achieve this effect (internal focus), results in an effective and efficient movement pattern. As a consequence, movement accuracy is enhanced.