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Cerebral cortical activity associated with non-experts' most accurate motor performance

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ABSTRACT

This study's specific aim was to determine if non-experts' most accurate motor performance is associated with verbal-analytic- and working memory-related cerebral cortical activity during motor preparation. To assess this, EEG was recorded from non-expert golfers executing putts; EEG spectral power and coherence were calculated for the epoch preceding putt execution; and spectral power and coherence for the five most accurate putts were contrasted with that for the five least accurate. Results revealed marked power in the theta frequency bandwidth at all cerebral cortical regions for the most accurate putts relative to the least accurate, and considerable power in the low-beta frequency bandwidth at the left temporal region for the most accurate compared to the least. As theta power is associated with working memory and low-beta power at the left temporal region with verbal analysis, results suggest non-experts' most accurate motor performance is associated with verbal-analytic- and working memory-related cerebral cortical activity during motor preparation.

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1. Introduction

1.1. Background

Thousands of hours of deliberate practice are required in order to achieve expertise in a motor task (e.g., golfing, bowling; Ericsson, Krampe, & Tesch-Romer, 1993). Given the extensive training requirements associated with the attainment of expertise, it is impossible for people to become experts in every motor task. Nonetheless, people choose to participate in motor tasks besides those at which they are expert; in fact, people participate in motor tasks at which they are non-expert (at novice skill levels). Examples of such people include those whose only golf experience comes at annual golf retreats, and those whose only bowling experience comes by playing a few times each year with his/her friends. Although non-experts' motor performance does not determine multimillion dollar contracts or Olympic medals like experts' performance does, non-experts still desire to perform as well as possible given their skill level. Despite this, little is known about the cerebral cortical activity associated with non-experts' most accurate motor performance. Notably, Landers et al. (1994) investigated cortical activity associated with 'novice' archers' most accurate performance. However, the authors only report the relationship between cortical activity and performance after the archers had completed 27 sessions of deliberate archery practice. Thus, the archers are not 'non-expert' as presently defined. Landers et al. observed that, after completing the practice sessions, the archers' most accurate performance was associated with cortical activity similar to that of experts. Given the robust relationship between cortical activity and accurate motor performance (for reviews of this literature, see Cooke, 2013; Hatfield, Haufler, Hung, & Spalding, 2004), addressing this shortcoming could inform non-experts how to maximize their performance. Therefore, the general purpose of the present study was to examine the cortical activity associated with non-experts' most accurate motor performance.

1.2. Cerebral cortical activity and motor performance of experts

Contrary to the lack of research concerning non-experts' cerebral cortical activity associated with their most accurate motor performance, a few studies have examined this relationship in skilled individuals (experts; Babiloni et al., 2008; Crews & Landers, 1993; Kao, Huang, & Hung, 2013; Loze, Collins, & Holmes, 2001). These studies have suggested experts' most accurate performance is associated with decreased inhibition of premotor, motor, and somatosensory cortical regions, increased inhibition of visual and visuospatial regions, as well as low levels of attentional control-related (e.g., working memory-related) cortical activity during motor preparation. In addition to these studies, several others have examined experts' cortical activity during motor preparation irrespective of performance outcome (see Cooke, 2013; Hatfield et al., 2004). This research has generally revealed that expert performers exhibit *little* verbal-analytic-related cortical activity (cortical activity believed to reflect verbal-analytic processes) during motor preparation. This is believed to result from an absence of verbal analysis about how to properly perform the task (i.e., an absence of 'instructional self-talk'), which may hinder experts' performance (Hatfield et al., 2004). Specifically, instructional self-talk is unnecessary for experts because they have cultivated highly developed 'motor programs' ('motor memories') that are housed in motor-related brain regions and that can be automatically engaged for accurate performance. As involvement of self-talk activates verbal-analytic brain regions, which are interconnected with motor regions, their activation may introduce unnecessary complexity into the otherwise automatic motor preparatory processes occurring in the motor regions. This likely disrupts the automatic motor processes, resulting in performance decrement.

1.3. Cerebral cortical activity and motor performance of non-experts

Relative to expert motor performers, non-experts exhibit more verbal-analytic-related cerebral cortical activity during motor preparation (Haufler, Spalding, Santa Maria, & Hatfield, 2000). Whether this cortical activity is associated with non-experts' most accurate performance is unknown. Theoret-