Effects of Anxiety on EEG coherence During Dart Throw

Jing Chen¹, Tsung-Min Hung¹, Jung-Huei Lin², Li-Chuan Lo¹, Jin-Fong Kao¹, Chiao-Ling Hung¹, Ying-Jung Chen¹, and Zen-Shing Lai¹
Taipei Physical Education College¹, National Ilan University², Taiwan

Key Words: Anxiety, EEG coherence, dart throw

Introduction

In competitive sports, most coaches and athletes agree on the significant effect of anxiety on performance. Although anxiety doesn’t necessarily have a negative effect on performance, it has been considered a major cause to poor performance. In contrast to anxiety, many top athletes and coaches reported the existence of a mental state that optimizes skilled performance. These athletes recounted their experience of this state as focused, timeless, free of thought, and totally immersed in the activity (Williams & Krane, 1998). The majority of scientific evidence for this mental state comes from phenomenological reports of athletes. Nevertheless, some researchers employed psychophysiological methods to study this phenomenon as well. Hatfield and his colleagues pioneered a series of such experiments by recording EEG during rifle shooting (Hatfield, Landers, & Ray, 1984). These authors found the reduction of brain activation in the left relative to the right temporal area prior to trigger pull and interpreted this shift of brain activation as a sign of neural processing efficiency. The efficiency interpretation was further supported by Haufler and her colleagues (2000). These authors compared cerebral cortical activation between expert marksmen and novice shooters during the aiming period and found less activation in the frontal, central, temporal, parietal, and occipital regions in the experts. The group difference was of greatest magnitude in the left temporal region and a similar temporal asymmetry to that observed earlier by Hatfield et al (1984) was absent in the novices. In this manner the experts accomplished the task in a more efficient manner as indicated by the EEG. No differences in cortical activation were observed between the groups when they performed cognitive tasks with which the groups were equally familiar suggesting that the task-specific EEG differences were achieved as a result of practice. Other studies also demonstrated neural efficiency was a result of practice (Kerick et al., 2004). In a similar vein, Deeny et al. (2003) applied EEG coherence to assess differences in the degree of cortico-cortical communication between several association regions of the cortex and the motor planning region (Fz) in two groups of highly experienced marksmen, who differed in competitive performance history. These authors observed lower Fz-T3 coherence in the superior competitors (no other differences in inter-electrode coherence were detected), which implied a decrease in cognitive involvement with motor processing. Collectively, these studies demonstrated a robust finding that skilled psychomotor performance was characterized by more efficient neural processing as reflected by EEG activity.

As aforementioned in the previous section, anxiety was considered a major cause to
poor performance. However, exactly how anxiety affect performance is still a question under examination. Masters’ (1992) reinvestment hypothesis postulated that stress or anxiety could induce conscious control, which interrupts the automaticity of skill execution. Accordingly, anxiety could result in a digression from the later, automatic stage to the earlier, cognitive control stage of skill learning. A test of the reinvestment hypothesis will require the examination of interaction among different cortical regions. Since skilled psychomotor performance is reflected by a reduction in unnecessary networking between cortical association and motor planning regions, one would hypothesis the digression to cognitive control under the influence of anxiety will be reflected by heightened EEG coherence between cortical association and motor planning regions. As such, the purpose of this study was to examine the effects of anxiety on EEG coherence during dart throw.

**Method and procedures**

**Participants:** Twenty-one male college students (aged between 20-27 years old) that were trained at dart throw for a minimum of three months were recruited. Participants were all right handed and free of neurological problem.

**Data recording and analysis:** Participants were required to perform 60 dart throws that were grouped into six blocks, ten dart each, on a standardized dart throw task in normal and anxiety condition. In anxiety condition, participants were given a baseline dart throw test in order to determine the criteria for monetary reward or electrical shock punishment. In addition, a digital video camera was set up approximately 45 degree on the left side of the participant to record their dart throw movement. Participants were told their movement would be analyzed afterward. This is to induce evaluation pressure on these participants. Dart throw performance and self-report data were compared using paired t test. EEG data were epoched 0.5 second consecutively for 2 seconds prior to the point of throwing movement. A 2×4×2 (condition by time by site) ANOVA with repeated measures was employed to evaluate the effect of anxiety on EEG $\alpha_1$ and $\alpha_2$ coherence separately. Greenhouse-Geiser correction procedure was applied if the sphericity assumption was violated.

**Results**

**Dart throw performance and self-report measures**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Normal condition</th>
<th>Anxiety condition</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dart throw score</td>
<td>8.20(.42)</td>
<td>7.94(.62)</td>
<td>2.83</td>
<td>.01</td>
</tr>
<tr>
<td>Dart throw SD</td>
<td>1.68(.36)</td>
<td>1.90(.42)</td>
<td>-2.57</td>
<td>.018</td>
</tr>
<tr>
<td>Cognitive anxiety</td>
<td>1.38(.48)</td>
<td>1.71(.71)</td>
<td>-4.105</td>
<td>.000</td>
</tr>
<tr>
<td>Somatic anxiety</td>
<td>2.07(.73)</td>
<td>2.24(.77)</td>
<td>-1.632</td>
<td>.117</td>
</tr>
<tr>
<td>Self-confidence</td>
<td>2.53(.32)</td>
<td>2.13(.46)</td>
<td>5.236</td>
<td>.000</td>
</tr>
</tbody>
</table>

**EEG**

$\alpha_1$ coherence, none of the three-way ANOVA effect showed significant effect.

$\alpha_2$ coherence, due the significant three-way interaction effect (F=3.396, p<.025, Eta$^2$=.167), the significant condition and time main effect were not further analyzed.
Follow up analysis revealed that, as shown in Figure 1 and 2, anxiety resulted in higher $\alpha_2$ coherence at Fz-T3. No such effect was observed at Fz-T4.

Figure 1. Condition effects on Fz-T3

Figure 2. Condition effects on Fz-T4

**Discussion**

This study intended to examine how anxiety affects psychomotor performance at the cortical level. Specifically, EEG coherence, a measure of cortico-cortical communication, was employed. The results support our hypothesis. Anxiety manipulation in the current study has successfully changed participants’ self-report anxiety score in the predicted direction. Dart throw performance was also impaired (e.g., 8.20 vs. 7.94) by the laboratory induced anxiety. Importantly, anxiety results in a heightened $\alpha_2$ coherence. This effect is only observed at Fz-T3. The higher coherence in anxiety condition implies more cortico-cortical communication between the verbal-analytical left temporal region (T3) and the motor planning frontal region (Fz). As suggested by previous researchers (Hatfield, et al., 2001), skilled psychomotor performance is characterized by efficient neural processing as manifested by a reduction in unnecessary networking between cortical association and motor planning regions during performance. The heightened coherence observed in the anxiety condition implies more cognitive interference from the verbal-analytical activity of the left temporal region to the motor planning frontal region. This finding supports Masters’ reinvestment hypothesis that maintains that stress or anxiety could induce conscious control, which interrupts the automaticity of skill execution.

**Conclusions**

Laboratory induced anxiety can increase self-report anxiety and have negative impacts on psychomotor performance. Anxiety also interrupts efficient neural processing by cognitive interference to the motor planning region.

**References**


