An Improved Cognitive Brain-Computer Interface for Patients with Amyotrophic Lateral Sclerosis


Introduction: Brain-computer interfaces (BCIs) are often based on the control of sensorimotor processes, yet sensorimotor processes are impaired in patients suffering from amyotrophic lateral sclerosis (ALS) [1]. Previously, we devised a novel paradigm that targets higher-level cognitive processes to transmit information from the user to the BCI [2]. The current work describes a refined version of this paradigm. We instructed five ALS patients (table 1) and eleven healthy subjects (6 female, mean age 28 years ± 7.5) to either activate self-referential memories by thinking of a positive memory, or to focus on a mental subtraction task, while recording a high-density electroencephalogram (EEG). We argue that both memories [3] and mental calculations [4] are likely to modulate activity in the default mode network (DMN) without involving sensorimotor pathways.

Table 1. ALS Patient Data

<table>
<thead>
<tr>
<th>Patient</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>75</td>
<td>54</td>
<td>NA</td>
<td>51</td>
<td>59</td>
</tr>
<tr>
<td>Sex</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>ALS-FRS-R</td>
<td>42</td>
<td>48</td>
<td>33</td>
<td>12</td>
<td>0</td>
</tr>
</tbody>
</table>

Discussion and Significance: The current study aimed to show that healthy subjects and ALS patients in various stages of the disease are able to use a cognitive paradigm for BCI control. Using a linear classifier, we were able to successfully distinguish a self-referential from a non-self-referential condition, with an average decoding of 97% separately for both healthy subjects and ALS patients. A one-tailed Wilcoxon signed-rank test rejected the null-hypothesis of a median classification accuracy on chance-level (50%) at p = 0.0015 for the combined subject groups. The presented work could serve as a novel tool which allows for simple, reliable communication to successfully distinguish a self-referential from a non-self-referential condition, with an average decoding of 97% separately for both healthy subjects and ALS patients.

References: