To Be (there) or Not to Be (there): The Influence of Object-presence versus Object-absence on Meaningful, Goal-directed Reach in a Mental Imagery Protocol using Brain-Computer Interface

Maggie McKone, OTS, Daniel Rortvedt, OTS, Julia Wilbarger, PhD & Dorothy F. Edwards, PhD

Background

Despite intensive rehabilitation following stroke, between 30-60% of individuals experience chronic motor impairments. One year post-stroke, 30-35% of individuals continue to experience impaired hand function, resulting in decreased participation in activities of daily living (Page, Levine, & Leonard, 2007).

Among available treatment methods for stroke rehabilitation, mental imagery is emerging as a viable option.

- Mental imagery involves the cognitive repetition of a physical task, usually without voluntary physical movement (Dijkerman, Ietswaart, Johnston, & MacWalter, 2004).
- Evidence suggests that the use of mental imagery improves functional hand performance in individuals with stroke (Page & Levine, 2007).
- Studies have shown significant increases in blood flow in premotor and frontal regions of the brain during mental imagery (Bruno, 1995).

There has been an overall lack of exploration of the most effective protocol for mental imagery. While research has shown external (visual or auditory) cues have enhanced performance during physical practice, there has been an overall lack of exploration of this effect during mental imagery (Heremans, et al, 2009).

Electro-encephalogram (EEG) based brain-computer interface (BCI) is often indicated as a method for translating thought into action. Mental imagery is a crucial component of EEG-based systems, and the quality of mental imagery influences individual performance with a BCI system (Mahmoudi, B., & Erfanian, A., 2006).

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Method

The most significant movement-related brain activity (imagined or actual) from each condition was reported as a higher r2 value. This indicates the areas of the brain that are most consistently activated across trials. All r2 values were derived using MATLAB.

Purpose and Hypothesis

To determine the effect of visual cueing on mental imagery and physical movement. To establish baseline values on healthy controls in order to tailor a mental imagery protocol for individuals with stroke.

There will be no difference between physical movement and mental imagery. Internal consistencies (r2 values) will be highest with a visual cue (object present) during mental imagery and movement conditions.

Results

Data Analysis: Specific channels (1-5, 9, 13, and 14) of the EEG cap were the main focus of our data analysis. These channels are located around the areas of the brain associated with movement (prefrontal cortex, supplementary motor area, primary motor cortex, somatosensory cortex, and cerebellum). The most significant movement-related brain activity (imagined or actual) from each condition was reported as a higher r2 value. This indicates the areas of the brain that are most consistently activated across trials. All r2 values were derived using MATLAB.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean r2 Value</th>
</tr>
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<tbody>
<tr>
<td>Cup</td>
<td>.380000</td>
</tr>
<tr>
<td>No Cup</td>
<td>.340000</td>
</tr>
</tbody>
</table>

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Discussion

Mental imagery with an object present yielded higher internal consistency (r2 value) than mental imagery without an object, confirming our original hypothesis.

During actual movement, internal consistency (r2 value) was lower when an object was present. This finding suggests that perhaps reaching for an object is more of an automatic response resulting in activation of fewer areas of the brain, whereas reaching for an object when it is absent may require more brain activation. These findings were opposite of our hypothesis.

While there were limitations with using healthy controls in our study, further limitations might occur for individuals with stroke. Because the protocol involves cognitive factors such as visual attention, it may be difficult to carry out with individuals who have had a stroke. Further, this may be important for individuals who have experienced a stroke in specific areas of the brain related to mental imagery.

Although the results were not statistically significant, they are promising. There appears to be an interaction between conditions. Future studies using more subjects and more trials would likely yield significant results.

Implications

Future BCI researchers might consider the influence of external cues and how the presence of an object might elicit different areas of the brain during mental imagery or physical practice.

Our results may also be applicable in clinical settings. Clinicians who choose to use mental imagery to supplement treatment might consider the benefit of having a functional object present during mental imagery.

This BCI protocol has the potential to be used to trigger a variety of occupation-based modalities, including functional electrical stimulation, to supplement treatment techniques and enhance recovery of muscle tissue for individuals with stroke.

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References

