P300 Brainpainting: Evaluation of a novel BCI application with ALS patients and healthy controls

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Introduction

To date, brain-computer interfaces (BCIs) are primarily used to enable (completely) paralyzed patients to communicate. However, these applications do not allow them to communicate in a creative manner; which many amyotrophic lateral sclerosis (ALS) patients would consider an increase of their quality of life. The current P300-Brainpainting application is intended to enable the patients to express themselves creatively by means of painting pictures only using their brain activity.

P300-BCI applications use the principle of an oddball paradigm. Rare events in a stream of frequent standard stimuli elicit a positive evoked potential (P300) at about 300 ms after the events.

A 6x8 matrix is shown to the user. For the P300-Speller (Fig.1), the small boxes of the matrix are filled with symbols like colours, shapes, transparency ranges, object size and grid size. During the selection process, the single columns and rows of the matrix start flashing in a random order and the subject has to concentrate on the desired symbol.

Previous research (Nijboer et al., 2008) showed the P300 spelling application is usable as an accurate means of communication in ALS patients; therefore it is a suitable reference to evaluate the accuracy of the P300-Brainpainting application.

Aims of Study

• To compare P300-Brainpainter accuracy with P300-Speller accuracy
• To compare P300-Brainpainter accuracy of ALS patients with that of healthy controls
• To assess motivation in patients and healthy controls

Results

1. For the group of healthy subjects, it was found that during copy-painting, significantly more errors were made than during the copy-spelling sessions ($p<.01$).

2. For the group of ALS-patients, the accuracy of copy-spelling and copy-painting was found to be similar.

3. ALS patients showed - compared to healthy subjects - lower accuracy in copy-spelling while the accuracy in copy-painting was higher.

4. ALS patients showed higher values for interest and challenge before the copy-painting session compared to healthy subjects.

Discussion & Conclusion

• High P300-Brainpainting accuracy was reached for both groups; however, the accuracy of the P300-Brainpainter was significantly lower than the accuracy of the P300-Speller in the group of healthy subjects. This could be because the two matrices differed in optical properties.

• Data of a new, adapted brainpainting matrix showed no difference in accuracy between P300-Brainpainting and P300-Spelling in healthy subjects.

• The group of ALS-patients showed no drop in accuracy while copy-painting; this could be due to higher values of interest and challenge.

• The high values for interest and challenge could be seen as indicator of the patients’ interest to express themselves creatively.

It can be concluded that the P300-Brainpainting application is accurately usable; with the new matrix, the same accuracy as during spelling can be achieved. Patients show interest in using the new application.

References


Participants & Method

1. a group of n=10 healthy participants (2 male, mean age 22.6 years, range 16-30 years)
2. a group of n=4 ALS patients (1 male, mean age 49.3 years, range 42-53 years)

The task was to copy-spell a pre-set sentence, to copy-paint a pre-set picture and afterwards to paint an individual picture. The pre-set sentence and the pre-set picture were matched in length (20 selections). Errors during the reproduction of the pre-given picture/sentence were noted. Motivation (mastery confidence, fear of incompetence, interest, challenge) was assessed before copy-spelling, before copy-painting and before free-painting (painting of an individual picture). Therefore, the German version of the “Questionnaire to assess current motivation in learning situations” was used.

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