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Adaptive assistance for BCI: a locked-in syndrome end-user case study

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Introduction: Performance variation is one of the main challenges that BCIs are confronted with, when being used over extended periods of time. Several methods have been proposed to find correlates of performance variation for sensorimotor rhythms EEG-based BCIs [1]. However, they typically focus on assessing performance variations within the same day or session, and do not use this information online. This issue is even more critical for end users, as they usually achieve a limited level of performance [2]. Previously, we proposed that some issues resulting from performance variation could be overcome by providing adaptive assistance based on the users' needs. Therefore, we suggested a method for providing online adaptive assistance (i.e., modulating the timeout to deliver the intended command) based on an estimation of the user's performance (i.e., the command delivery time, CDT, for a single trial) [3]. We previously reported results on able-bodied subjects (N=9). Here, we test the approach with an end-user with locked-in syndrome.

Material, Methods and Results: We conducted several experimental sessions, each on a different day, using a motor imagery (MI)-based BCI in a game. The subject was 53 years old, suffering incomplete locked-in syndrome after hemorrhagic brainstem stroke in 2009. The experiment was performed in two phases: the first one (6 sessions), with no assistance, which was used to build the performance estimator, and the second one (10 sessions), where online adaptive assistance was provided to the user. In order to predict the CDT, trials shorter and longer than 3 s were considered as short and long, respectively. The performance estimator used PSD features in a short time window (1 s) at the beginning of the mental task execution trial and a linear discriminant analysis classifier to differentiate between short and long CDT with a reliable performance (AUC = 0.8). In the next phase, 10 sessions of the experiment were conducted in order to assess the feasibility of providing adaptive assistance based on the estimated performance by modulating the timeout for delivering a mental command. Two conditions were compared: having a *fixed timeout* (3 s) and providing *adaptive assistance* when the user needs it (by providing a longer timeout of 10 s in case the performance estimator predicts a long CDT). Details of the experiment and the methods can be found in [3]. As depicted in Fig. 1, providing adaptive assistance leads to significantly higher success rate (the ratio of correct command delivery to the number of commands) in the MI task ($p<0.005$; Wilcoxon ranksum test) over sessions (S1 to S10).

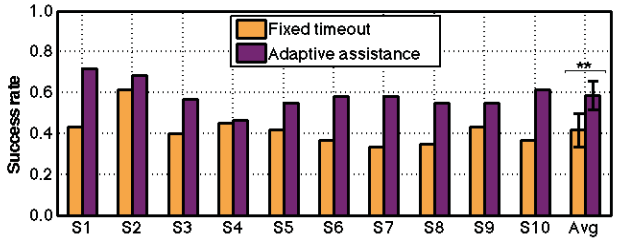

Figure 1. *Comparison of the success rate (ratio of correct command delivery to the number of commands) over 10 sessions (days) in two cases: fixed timeout and online adaptive assistance.*

Discussion: The proposed performance estimator overcomes some limitations of the existing studies on performance variation by taking into account several sessions of online MI experiment for building the estimator and providing a trial-based estimation. In addition, providing online adaptive assistance based on the users' needs at each time is shown to improve success rate.

Significance: This study proposes a method for estimating the performance of an MI BCI on a single trial basis as a mechanism to deal with the performance variability of BCI users, especially severely disabled ones. Importantly, promising results are achieved when providing online adaptive assistance based on this estimation in both able-bodied subjects and an end-user with locked-in-syndrome.

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