Why and How to Use Intelligent Tutoring Systems to Adapt MI-BCI Training to Each User

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Introduction: While Mental Imagery based BCIs (MI-BCIs) are promising for many applications, their usability "out-of-the-lab" has been questioned due to their lack of reliability: literature reports that 15% to 30% of users cannot control such a technology, while most of the remaining users obtain only modest performances [1]. Standard MI-BCI training protocols have been suggested to be partly responsible for these modest performances as they do not comply with general human learning principles [2]. The modest performances as well as the flaws in the protocols led to the investigation of solutions to improve MI-BCI training by adapting it to each user. Such an approach is possible using Intelligent Tutoring Systems (ITS), i.e., computerised systems aiming at supporting learning [3]. Hence, we show **why** ITS are relevant for MI-BCI training and **how** this technology could be used.

Why? – MI-BCI training resembles *distance learning* (DL) as it is performed autonomously, with neither teacher nor classmates. Consistently with DL literature, highly anxious and poorly autonomous learners have been shown to struggle with MI-BCI training [5]. Since ITS have been proven efficient for improving DL [3], MI-BCI training may also benefit from ITS. The strength of ITS lies in (1) a personalised support provided by a learning companion [3] and (2) an adaptation of the training process according to the learner's profile and skill evolution.

How? - We are proposing the conceptual framework for an ITS which would support MI-BCI user-training. ITS comprise 4 modules. First, the *Student Model* is the core component containing information about the user's personality and cognitive profile and state. Second, the *Expert module* contains the concepts, rules and strategies of the field to be learned. Third, the *Tutoring module* uses input from the two previous modules to select a tutoring strategy, and finally the *Interface* provides the user with access to the learning environment. Each module will be described in an MI-BCI training context (see Fig.1). The *Student Model* contains 2 kinds of information: 1) the user-profile, as assessed by questionnaires, and more specifically spatial abilities and personality traits (e.g., abstractness, tension or autonomy), which have been shown to be related to MI-BCI performance [4]; and 2), the user's cognitive state, e.g., fatigue and workload levels and MI-BCI skill development, provided by the BCI system through classification-accuracy measures. The *Expert module* contains a cognitive model of the skills to be learned, e.g., the ability to generate stable and distinct brain-activity patterns while performing the MI-tasks. It also includes a bank of exercises with different levels of difficulty [6], which would help the user to acquire these skills. Based on the *Student Model* and on the *Expert module*, and using specialised algorithms [3], the *Tutor* selects the appropriate exercises and provides the users with a suitable support, i.e., adapted to their performance and profile. This support will be provided using a physical learning companion [3], which has been proven to increase motivation and learning [3]. In particular, this companion will provide any users who have high tension and low autonomy levels [4] with a social presence and an emotional support (e.g., empathy). We are currently designing and evaluating the content of these different modules.

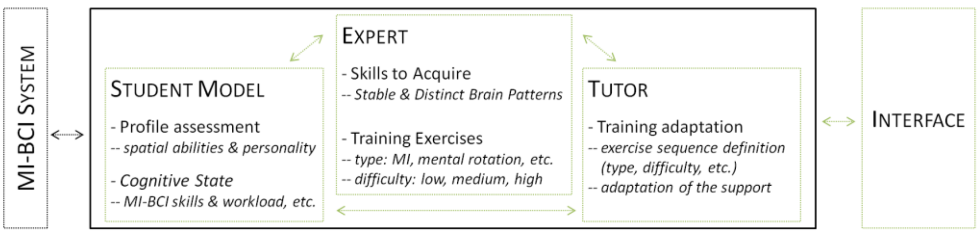

Figure 1. *Diagram representing the conceptual architecture of an ITS supporting MI-BCI training.*

Discussion: ITS may be very useful for MI-BCI user training, especially if the *Student Model* and *Expert module* are reinforced. The former could include more detail on the user's profile and cognitive state, while the latter could be improved by a better fundamental understanding of MI-BCI related skills and how they are acquired.

Significance: Such an ITS represents a promising pluridisciplinary approach for improving MI-BCI performance as it would enable to gather different levers and articulate them in order to optimise the user-training process.

References

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