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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.

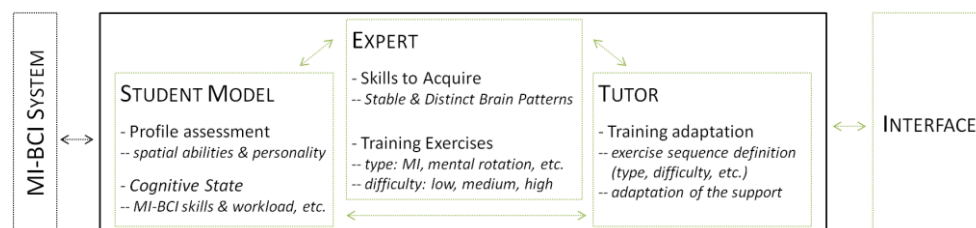


Figure 1. Diagram representing the conceptual architecture of an ITS supporting MI-BCI training.

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.

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