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Improving User Experience and Performance through Gamification of MI-BCI Training

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Introduction: Motor Imagery Brain-Computer Interfaces (MI-BCI) decode brain patterns associated with motor intentions into control commands for a variety of applications, bypassing traditional motor inputs. To use these systems, the user must produce identifiable and stable MI patterns [1], which requires multiple training sessions in a lab. However, MI-BCI training protocols are often repetitive and suboptimal as some users remain incapable of BCI control. This problem, known as **BCI illiteracy/deficiency** [2, 3], has been related to psychological and cognitive factors such as motivation and attention [1, 4]. While some studies have tried to improve users' MI skills and BCI performance through enriched feedback [5] or motor priming [6], a unified protocol that considers various aspects of user training has not yet been introduced.

Potential solutions: The current study aims to develop a more user-centered MI-BCI training protocol by implementing principles from human-computer interaction and game design. Through a systematic review, we examine how gamification of user training can improve user experience and BCI performance. Here, gamification refers to the use of game elements such as interactive objects, goals, and rewards, which can make BCI training more engaging, motivating, and effective [4, 7, 8]. A potential platform for such a BCI training game is virtual reality (VR). Not only does VR offer richer, immersive feedback during BCI training, it can also embody the user into a virtual character, giving them more agency over virtual movements performed with the BCI [8, 9]. We discuss how virtual environments have been used in MI-BCI training in combination with gamification, and introduce empirical studies that can further incorporate and test a gamified VR MI-BCI training protocol.

Significance: An overview of effective design principles for MI-BCI training can provide future BCI researchers and developers with a framework for creating more engaging and effective protocols that reduce the BCI inefficiency problem and accelerate the technology's mainstream adoption.

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