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The History and Future of (Re) Defining BCIs

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Introduction: The term "brain-computer interface" and acronym "BCI" have become hot commodities. As BCIs and similar systems become more prominent and powerful, more companies, labs, and other groups will want to expand the definition of "BCI" to include systems that they sell, research, or otherwise promote. In science, engineering, and medicine, definitions are crucial for many reasons. Indeed, several efforts have been made to define BCIs, including clarifying key elements like sending information directly from a brain to a computer, providing feedback to the user, and (near) real-time operation [e.g., 1, 2]. However, other efforts have tried to redefine BCIs. Here, we address these efforts, introduce categories of redefinition approaches, and review why this issue matters.

Material, Methods and Results: We reviewed dozens of peer-reviewed articles and other materials that present or discuss the definition of a BCI. The term and acronym were introduced in the first peer-reviewed paper that described a working BCI [3], but this article did not focus on the definition. The first two reviews of BCIs did address the BCI definition [4,5], including key elements such as sending messages directly from the brain to an external device. Soon thereafter, the EU funded two major projects devoted partly to defining BCIs and associated terms [6,7]. IEEE developed a definition a few years ago [8]. The BCI Society devoted a major effort to the BCI definition in 2024, resulting in a definition similar to canon that represents the views of its 445 members at the time of voting [9]. Nonetheless, efforts to broaden the BCI definition continue, most recently and notoriously through [10].

We identify consistent approaches to (re)defining BCI and problems with them. Unsurprisingly, these efforts always try to expand the definition to add the non-BCI systems that its proponents use. Approaches may be nominal, focusing on the term itself. This approach ignores the well-known underlying problems with this term; if we go by the name alone, a keyboard or mouse provides an interface from a brain to a computer. We prefer a canonical approach that considers which systems have been presented as BCIs in conferences, papers, talks, and other mechanisms as well as established definitions. Other approaches include fatalistic, arguing that efforts to define BCI will inevitably be misconstrued by journalists and the public, or financial, which posits that a broader definition would encourage more funding (without mentioning that it would also increase the number of people seeking funding). Arguments have also been made that definitions should be inclusive to avoid hurt feelings.

Conclusion: Efforts to redefine BCIs will continue and elicit growing controversy. These redefinition efforts will rarely succeed in establishing a new definition that meets the expectations of its proponents. However, they will succeed in: fomenting and conveying fragmentation; necessitating discussions and replies; and confusing important groups including funding agencies, regulators, journalists, companies, researchers, medical and BCI practitioners, patients, students, instructors, and the public at large.

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