

# Survey Results Regarding BCI Terminology

Brendan Allison<sup>1,2,\*</sup>, Jane Huggins<sup>3</sup> and Jaime Pineda<sup>1</sup>

<sup>1</sup>Cognitive Science Department, University of California, San Diego, USA

<sup>2</sup>Electrical and Computer Engineering Department, Old Dominion University, Norfolk, USA

<sup>3</sup>Department of Physical Medicine and Rehabilitation and Department of Biomedical Engineering, University of Michigan, Ann Arbor, USA

ballison@ucsd.edu, janeh@umich.edu, pineda@ucsd.edu

## Abstract

Different groups and projects have discussed official definitions and terms within the BCI community. We presented a survey at the Fifth BCI Meeting in 2013 that included a section on terminology. This paper discusses results to questions about the term “BCI” and its essential features, and terms such as “BCI Illiteracy”, “BCI inefficiency” or “BCI Proficiency”. While most respondents agreed on the term “BCI”, replies otherwise reflected significant disagreement. These survey results may facilitate discussion and understanding of different viewpoints, and encourage consensus on key terms and definitions.

## 1 Introduction

The term “Brain-Computer Interface” or BCI has been in use since the 1970s (Vidal, 1973). Numerous definitions of the term have been presented in the published literature and elsewhere. In addition, many other terms have been used to describe similar systems, such as “Direct Brain Interface,” “Brain-Machine Interface,” and “Brain Interface”. As BCI research gains attention in academic, commercial, medical, and other sectors, it seems increasingly important that we agree what a BCI is. A standardized definition is an obvious prerequisite for a mature field, and should not be especially daunting for a field dominated by scientists, engineers, and clinicians.

Other BCI researchers have agreed that a standardized definition is important. At the Fourth International BCI Meeting at the Asilomar Conference Grounds in Pacific Grove, California in 2010, over 65% of survey respondents felt that a standard definition of a BCI is needed within two years, and 79% felt that one is needed within five years (Nijboer et al., 2011). At the Fifth International BCI Meeting in the same location in June 2013 (organized by the Program Organization Committee for the Fifth International BCI Meeting), attendees unanimously voted to establish a BCI Society. This Society has actively sought to explore a BCI definition through online discussions, workshops at the BNCI Horizon 2020 retreat in Hallstadt, Austria in March 2014 (organized by the Graz University of Technology through the BNCI Horizon 2020 project), and other mechanisms. EU-funded projects, including two Coordination and Support actions called Future BNCI (2010-2011) and BNCI Horizon 2020 (2013-2015) have also been charged with developing, publicizing, and entrenching a standard BCI definition. This paper presents some results from a survey we conducted at the Fifth International BCI Meeting focused on two terminological issues – the definitions of “BCI” and “BCI Illiteracy”.

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\* To whom correspondence should be addressed.

## 2 BCI: Term and Key Features

Our survey contained seven sections, and section three was titled “Terminology.” The first question asked: “Which term should be used to label BCIs?” 123 people answered this question. 93 people chose “Brain Computer Interface (BCI),” 24 people chose “Brain Machine Interface (BMI),” and the last two choices, “Direct Neural Interface” and “Brain-Neuronal Computer Interaction” each got three votes. Hence, consistent with our prior survey, results indicate a strong preference for the term BCI, with BMI a distant second and very little support for other terms (Nijboer et al., 2011).

The next question asked: “Which of the following elements is essential in a BCI? In other words: devices that do not have these elements are not BCIs. (Please check all that apply)” Table 1 summarizes the results.

Characteristic	# of respondents	% of respondents
<b>Must detect brain activity directly (before signal goes through peripheral nerves and muscles)</b>	101	77.10
<b>Must classify brain activity</b>	80	61.07
<b>Provides feedback to the user based (at least partly) on brain activity</b>	76	58.02
<b>Provides feedback in real-time, or near real-time</b>	76	58.02
<b>User must make voluntary choice to send each message or command</b>	43	32.82

**Table 1:** Essential components of a BCI, according to survey respondents.

These results reflect strong disagreement over the critical features of a BCI. These results echo the 2010 survey, which also found that respondents had widely divergent views. Other efforts to summarize different views of BCI components have also been presented (See Fig. 1). This figure was developed through discussion among the team that proposed and later executed the Future BNCI project, and reflects the efforts of several BCI experts to define critical features to foster discussion. This figure is consistent with the newer results presented above. Most respondents felt that a BCI must directly detect brain activity, but generally disagreed with the “intentional” component below.

A BCI requires four components:

- 1) Direct
- 2) Realtime
- 3) Realtime feedback
- 4) Intentional



**Figure 1:** The four components of a BCI, as defined in the proposal for the Future BNCI project, submitted in 2009. The project was active from Jan 2010 to Dec 2012 and extensively discussed the definition of a BCI and how to encourage an “official” definition within the field.

### 3 “BCI Illiteracy”

One of the most consistent challenges in BCI research has been dubbed “BCI Illiteracy” (Kübler and Müller, 2007). That is, a minority of users cannot use any particular BCI system, and may be as high as 20% (among healthy users) with some BCI approaches (Allison and Neuper, 2010). This problem has persisted since the earliest days of BCI research, across a wide variety of different types of sensors, mental activities and corresponding changes in brain activity, signal processing parameters, and other BCI features. This problem can be especially daunting for home use with less sophisticated systems. Several publications have argued that reliability is one of the most serious problems in the BCI community (e.g., Huggins et al., 2011, Wolpaw and Wolpaw, 2012; Allison et al., 2013).

At many BCI conferences and other discussion forums, many people have expressed concern about the term “BCI Illiteracy,” arguing that it is vague or implies that the problem should be blamed on the user. “We asked: Sometimes, a BCI system does not work for a particular user. Different terms have been used in the literature to describe this problem. What term do you prefer?” Of the 107 responses, 32 chose “BCI Illiteracy,” 33 chose “BCI Inefficiency,” 13 chose “BCI apraxia” and 29 chose “Poor BCI Proficiency.” These results indicate considerable disagreement over the best term to describe this phenomenon. Many respondents commented on this question, emphasizing that (as several people replied), “It is not the user’s fault!” We authors strongly agree and hope we can agree on a term that is descriptive and avoids blaming the user.

### 4 Summary and Comments

As with our 2010 survey, we have some concerns about our survey that could improve future survey efforts. Respondents were anonymous, which could lead to problems like multiple votes per person or “joke” voting. Some respondents did not answer all questions, and hence a shorter and more focused survey might have produced different results. Similarly, a longer survey might have elucidated more topics. Although we made a strong effort to present questions fairly, some biases in the questions and answer choices were present nonetheless. For example, the question about which term should describe BCIs explicitly used that term, and the question was asked at a conference with “BCI” in the name. New surveys might find new results among different venues and respondents.

These results show that respondents generally agree that the term “BCI” is preferable to other options such as “BMI”. However, there remains little agreement on what constitutes a BCI. Similarly, the community has divided views on which term should be used when someone can’t use a BCI. Part of the problem stems from the acronym itself – the term could refer to a very wide variety of systems. Characteristics such as feedback or closed-loop operation are not obvious from the acronym. Notably, many other terms within the BCI community, such as “synchronous” or “SSVEP” are not controversial, perhaps largely because these terms inherently specify defining characteristics.

We are concerned about the lack of accord on important terminological issues. The term “BCI” might be misused to gain attention, grant funding, or sales. Clear terms and definitions could help educate students, foster efficient discussion and collaboration, provide clear information to patients and other end users, and identify relevant publications. Thus, we encourage efforts to develop standard terms and definitions, including the emerging BCI Society (Ramsey et al., 2014) and BNCI Horizon 2020 Project. For example, the BNCI Horizon 2020 retreat included new surveys and six focus groups that discussed the BCI definition. We also hope to encourage effective interaction by better defining essential characteristics of a BCI, which can help people consider resulting examples of what is, or is not, a BCI. Our complete survey included follow-up questions that presented examples of systems that included different characteristics and asked respondents to consider whether

each example is a BCI. Such efforts might encourage more focused surveys, discussions in person and online, and other efforts to find consensus. The nascent BCI Society has also been discussing the BCI definition, and may consider actions such as forming a panel with an appropriate range of different people to develop official terms and definitions for the Society. We hope to work with our colleagues to reach consensus acceptable to most (if not all) of us in the BCI community.

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