

# A Preliminary Survey on the Perception of Marketability of Brain-Computer Interfaces (BCI) and Initial Development of a Repository of BCI Companies

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## Abstract

The marketability of BCI applications may greatly influence the decisions of governments, the industry and academia. In this paper we first explored with a survey when respondents ( $N = 145$ ), who were present at the 4th International BCI Meeting, expect that different BCI applications will become commercially available. Second, we surveyed how well existing BCI companies are known to respondents. Third, we compared the findings with our own preliminary overview of the marketability of BCIs and our repository of 28 companies. Respondents were optimistic about the marketability of BCIs for healthy users and users who need assistive technology (AT), but 72.4% of the respondents was unaware that companies already exist which market BCI's. Based on a preliminary market overview we cautiously suggest that optimism in relation to applications for healthy users is more appropriate than in relation to BCI-based AT. In future we plan surveys among a broader range of stakeholders and more profound analyses of the market.

## 1 Introduction

Brain-Computer Interface (BCI) research is rapidly increasing, with considerable enthusiasm for applications for users with and without physical disabilities [1, 2]. A roadmap for BCI research and development could help address emerging markets and opportunities. The future Brain/Neuronal Computer Interaction project (fBNCI; <http://future-bnci.org/>) aims to develop such a roadmap by drawing on the expertise of BCI researchers, as well as many other stakeholder groups, including companies, end users, patient organizations, policy makers, and the general public. One focus of the roadmap is to evaluate the marketability of current and future BCI applications. Hence, we surveyed researchers on the marketability of BCIs at the 4th International BCI Meeting, which took place at the Asilomar conference centre in June 2010. This conference provided an excellent opportunity to engage many qualified respondents, although it has to be noted that many other qualified respondents (e.g. from the field of human-computer interaction or ambient intelligence) do not typically attend this meeting which may bias our findings (see Section 5). Other results from this survey and more demographical data of the respondents are available elsewhere ([3]) and under review ([4]). In this paper we focus on three aspects of the survey. First, we explored when respondents expect that different BCI applications will become commercially available (see Section 3.1). Second, we surveyed how well existing BCI companies are known to respondents (see Section 3.2). Third, we compared the findings with our own preliminary overview of the marketability of BCIs and our repository of companies (see Section 3.3).

## 2 Methods

A total of 145 (105 males, 39 females) out of 289 conference attendees responded to the questions about the marketability of BCIs. Seventy three persons were aged between 18 and 30, sixty-nine persons between 31 and 55 and two persons were aged between 56 and 70. The sample consisted of experts from various disciplines (e.g. neuro-, computer or cognitive scientists, electrical engineers, psychologists etc). One participant did not give demographical data.

Participants completed an online survey that included four questions on the expected marketability of different purpose BCIs. In the survey, for convenience, we ordered some BCI types based on their function: 1) BCIs for healthy users, 2) BCIs as AT, 3) BCI-controlled prostheses and 4) BCIs as therapy tools.

Specifically, participants were asked to indicate when they expected to see these types of BCI systems to become available on the market. Participants could choose from 5 answer options: “never”, “between 0–5 years”, “between 5–10 years”, “more than 10 years” or “it already exists on the market”. Participants who indicated that this type of BCI already exists on the market were asked which group or company offers the product.

Only companies which offered BCI products and services were included in the repository. Thus, companies supplying hardware and software needed for BCI research were not included. The repository was build through: 1) web searches, 2) written and verbal interviews of experts and 3) iterative postings on LinkedIn groups (“brain-computer interface group”, “neuromarketing” and “BrainGain”).

## 3 Results

### 3.1 Respondents’ Expectancies of Marketability of BCI

Table 1 presents the respondents’ expectancies per BCI class.

BNCI technology for:	on market	0–5 yrs	6–10 yrs	> 10 yrs	never	# of resps
healthy users	26.6 %	44.8 %	13.8 %	12.4 %	1.4 %	145
users who need AT	16.6 %	42.1 %	33.8 %	7.6 %	0.0 %	145
users who need prostheses	0.7 %	20 %	43.4 %	34.5 %	1.4 %	145
users who need therapy	9.9 %	39.4 %	39.4 %	10.6 %	0.7 %	142

Table 1: Overview of percentage of respondent which indicated when BCI applications will enter (if ever) the market for healthy users, users who need AT, prostheses and therapy. The last column shows the number of respondents (# of resps) who rated the item.

### 3.2 Respondents’ Knowledge About Existing Companies

Thirty-two respondents reported which companies they knew that already marketed BCI’s for health users. By far the best known companies are Neurosky (counted 13 times) and Emotiv (counted 14 times). Other companies that were mentioned: Hitachi, Ambient, OCZ technology, Starwars Science, Mattel, inc., g.Tec, Brain Actuated Technologies, InteraXon, Zeo, inc. and Interactive Productline. Twenty-two respondents reported which companies they knew that already marketed BCIs as AT. The best-known company is g.Tec (counted 16 times). Other groups and companies that respondents listed were: Ambient, Brain Actuated Technologies, OpenVibe and BCI2000. Nine respondents commented that they knew BCI’s as therapy tools already are on the market, but only two gave concrete company names: Brain master Technologies, inc. and EEGinfo. None of the respondents identified a company that already markets BCI-based prostheses.

### 3.3 Preliminary Overview of Companies and Marketability

We summarized a preliminary overview of 28 companies related to Brain-Computer Interfacing (see Figure 1), which we expect to be more complete at the time of the Graz conference. Currently, neurofeedback companies are not yet listed in the repository. We invite all readers to comment on this overview and continue completing and criticizing the overview so we can offer the European Commission the most accurate summary possible. This overview currently shows that as many as 10 companies market BNCI's for entertainment and gaming. Six companies offer BNCI as AT, although two of these companies (Neural Signals, inc and BitBrain) do not yet market products. However, there is a big difference in the number of products sold between the two markets. Neurosky, for example, has sold approximately 1 million Mindsets, whereas g.Tec has sold between 30–40 Intendixes (personal communication). Our survey did not address neuromarketing. We counted six companies in this area. BCI researchers ( $N = 144$ ) have divided opinions on whether neuromarketing technologies do (35.4%) or do not count (47.9%) as BCI systems (Nijboer et al, in review). Nevertheless, neuromarketing developments influence BCIs, and it is predicted that this market will grow tremendously [2, 5]. Finally, two companies (Brain Fingerprinting inc. and No Lie MRI) provide BCI services for criminal investigation.

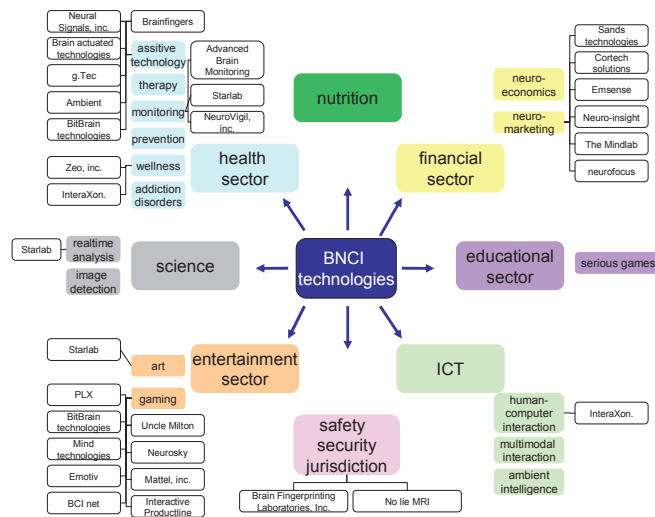


Figure 1: Preliminary overview of existing companies.

## 4 Discussion and Conclusion

The survey results show that respondents were generally optimistic about the near-term marketability of BCI's for healthy users and user in need of AT. Repondents were slightly less optimistic about BCIs for therapy and expect BCI-controlled neuroprostheses to require more than 10 years to enter the market. Our preliminary overview shows that companies - more than respondents realize - already market BCIs for healthy users and users who need AT. However, having a product on the market does not yet mean that a product is sold successfully. BCI research toward AT has a history of several decennia yet 30–40 products were sold by g.Tec. BCIs for healthy users are available since less than 5 years and (at least) more than a million products have been sold. It is remarkable that 72.4% of the respondents are not aware that BCIs for healthy users are already on the market. Since 10 companies already exist in this direction we argue that optimism for this type of applications is quite appropriate. In our opinion BNCI for AT is not

likely to create large economic value, unless it becomes available for a broader range of categories of (more numerous) end-users. The societal value of AT-BCI products is enormous, since they can enable users with disabilities to participate in the society at interpersonal and professional levels. However, we predict that the research and development of BCIs targeted at the general public will more easily mobilize the industry and facilitate the tech transfer between universities and industry. This will lead to more acceptance of BNCI technology in the public and possibly to a spillover to the AT industry. In addition, even though the market for BCI-controlled prosthetics requires a more time-consuming trajectory, ultimately we expect these products to create large economic and societal value similar to Deep Brain Stimulation, because the number of potential end-users is relatively high.

The survey reported here contains some flaws. First, since we could not make the entire survey too time-consuming, some questions were generalized. For instance, we did not specify whether the BCI products would work with non-invasive or invasive brain signals nor did we consider the usability of different BCIs. However, these specifications would influence the cost, number of available users, training time, time to market and many other factors. Second, the respondents were mostly people involved primarily in BCI research and had the time, funds, and enthusiasm to attend a major conference, so the sample may be positively biased. fBNCI in future will survey a broader range of stakeholders, including more experts from human-computer interaction and the industry.

Although we view these data as a first crude estimation of the fields' perception of marketability of BCIs, we cautiously conclude that BCI researchers seem optimistic about how much time it will take before the first BCIs for non-medical purposes and AT enter the market. We agree with them that the market for BNCI applications for healthy users is promising, but we are not convinced that the market for AT-BCI applications is equally promising simply because the number of end-users is relatively low in comparison. Moreover, the limited knowledge of respondents about existing companies should raise awareness in the BCI community that tech transfer is already well established largely without the involvement of the scientists who consider themselves the core of the BCI field. A more pro-active role of BCI scientists in tech transfer would be desirable for high quality product development.

## 5 Acknowledgments

The authors gratefully acknowledge the support the Future BNCI project (Project number ICT-248320) and of the BrainGain Smart Mix Program. We thank all respondents and Thorsten Zander, Jan van Erp, Yann Renard, Fabien Lotte, Ariel Garten, Tom Sullivan, Christoph Guger and Hendri Hondorp for valuable input.

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