# The Applicability of Neurally-Controlled Devices in Business: A Student Perspective

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#### Abstract

Neurophysiological tools are receiving increased attention in the field of information systems and by organizations to provide new modes of interaction with computers and more insights into the minds of end-users and customers. Academics and members of private industry are leading the charge with new research streams and systems development efforts, but what do our future contributors to society think about these advances and their applicability to business? A preliminary study is presented from a qualitative analysis of responses from twenty students in a college survey course on information systems. Emerging themes include an appreciation for the swift advances being made with neurally-controlled devices, technical limitations, advantageous uses for assistive technology, viable applications for business and medicine, concerns for security, fear of unintended societal consequences, competitive devices, and belief that this is all still science-fiction. These themes highlight opportunities for aligning research and development efforts.

#### 1. Introduction

The field of information systems (IS) has long struggled with a balance between methodological rigor and relevance to practice [1]. This debate naturally extends to its emerging sub-fields, including that of neuro-IS [2]. Neuro-IS has evolved by examining how neuroscience methods can inform IS and human-computer interaction (HCI) [3, 4]. Information Systems researchers and developers are using neurophysiological tools to better understand end-users of systems and their thought-processes when making complex decisions [5-7], as well as examining new modes of interaction with computers through neural input [8]. However, with such niche areas, these researchers and developers may be concerned that they are in fact exploring avenues of interest and applicability to the general public.

Here is presented a preliminary, qualitative study that begins to uncover topics of relevance to the general business community regarding the application of neurophysiological tools. College business students offer perspectives on their future workplaces and society as influenced by devices fueled with neural input. Such students are future contributors in our business organizations and potential end-users and customers of our breakthrough technologies. Hearing their views allows us to keep our efforts in sync.

## 2. Common Neurophysiological Tools

Non-invasive techniques for recording neural activations involve sensors placed on the skin's surface for signal acquisition instead of using surgically-implanted electrodes. One of the most common of these approaches is the use of electroencephalography (EEG), a bio-recording technique that measures electrical activity of the brain collected from scalp electrodes. Used for years in the medical community, EEG is moving from the clinical setting into the real world to control computers with the human mind, as with braincomputer interfaces (BCIs) [4, 8, 9], and to better understand human mental processes in organizational settings [10, 11]. Other approaches include the use of functional magnetic resonance imaging (fMRI) as a non-invasive method for measuring oxygenated blood volume using a powerful, magnetized probe that can reflect activity throughout the brain and functional near-infrared (fNIR) which also measures oxygenated blood volume in the brain but using nearinfrared light reflections [12].

Electroencephalography and fMRI have a growing presence in areas of business like marketing, economics, and now IS [3]. Such techniques are being used to gauge people's deeper reactions to various stimuli and understand their decision-making processes [5, 11, 13, 14]. In addition, these tools are being integrated into applications for cognitively aware computer interfaces, Internet browsing, video gaming, and assistive technology [10, 15-17].

## 3. Preliminary Study

This qualitative study explored what could be discovered from an inquiry to business students about the future applicability of neurally-controlled devices on business. The students were newly exposed to the related concepts by the instructor who actively engaged in related research.

#### 3.1 Participants

In total, 480 students were surveyed from a general course on IS across four consecutive semesters during 2009-2011 about their perspectives on the future applicability of neurally-controlled devices on business. Analysis here covers 20 of the respondents taken from the most recent semester polled in 2011 as an initial exploration of emergent themes. Of the twenty respondents, there were 14 females and 6 males with an average age of 25 (range of 22-33 years old). Majors included: Accounting, International Business, Finance, Management, Marketing, and Professional Sales (at the time surveyed, there was not an IS major in business). Students were in their junior or senior year.

The course is a required course for all undergraduate business majors to graduate and has been in place for over seven years at the institution. The course was administered at a large university in a city in the southeast of the United States with direct access to a major metropolitan area and numerous partnerships with local and international businesses.

#### 3.2 Data Collection & Analysis

Students read an article published online in March 2008 about a device demonstrated at a Texas Instruments developers' conference that allowed voiceless phone calls to be made using nerve connections in the vocal cords, a form of a BCI. There was an accompanying video that lasted 3 minutes and 27 seconds where the developer demonstrated his product. After reading and reflecting on the article, students asynchronously shared their written responses via an online course management tool's discussion board. The related discussion topic was available for submission over the span of two months near the end of the semester. Student responses counted as part of their class participation grade; contributions for this assignment were worth 5 points of the total grade for the course

out of 1000 points. Specific instructions provided to students were as follows:

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Please share your thoughts about the
article: "Nerve-tapping neckband used in
'telepathic' chat" found at:
http://www.newscientist.com/article/dn13449.
How might advances such as this, where
computers can be controlled by your thoughts
(i.e., brain-computer interfaces), affect
the future of business? You should make
meaningful and thoughtful contributions to
the discussion. Please do not repeat
comments made by others.
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Text responses were compiled from the first and last ten respondents (total of 20) to the discussion topic. Text was cleaned by removing stray characters inserted from HTML-based formatting, correcting for spelling, and removing repeated words (e.g., the the). The average word count for responses was 130. General descriptives were noted for respondents (e.g., age, gender, major). Responses were then examined individually for key themes captured in the form of codes. These codes and themes were not established *a priori* but rather emerged from the data.

## 4. Results

Table 1 presents the 19 initial codes that emerged from the data and the number of times they appeared in the responses.

No.	Code	Count
1	Assistive Technology	14
2	Technical Advancements	9
3	Intrigue	8
4	Limitations	7
5	Skepticism	6
6	Optimism	6
7	Business Applications	5
8	Security	4
9	Misuse	3
10	Inapplicable for Able-Bodied	3
11	Science-Fiction	2
12	Medical Applications	2
13	Human Interaction	2
14	Fear	2
15	Consequences	2
16	Competition	2
17	Alternatives	2
18	Reliability	1
19	Brain Complexity	1
	TOTAL	81

Table 1. Initial codes from responses.

These codes were then condensed down to the 8 themes highlighted in Table 2. These themes include

appreciation for the swift advances being made with neurally-controlled devices, technical limitations, advantageous uses for assistive technology, viable applications for business and medicine, concerns for security, fear of unintended societal consequences, competitive devices, and belief that this is all still science-fiction.

INO.	Ineme	Code	
		Technical Advancements	
		Intrigue	
		Optimism	
1	Advancements	Brain Complexity	
		Limitations	
		Skepticism	
		Inapplicable for Able-	
		Bodied	
2	Limitations	Reliability	
3	Assistive Technology	Assistive Technology	
		<b>Business Applications</b>	
4	General Applications	Medical Applications	
		Security	
5	Security	Misuse	
		Fear	
	Fear of Unintended	Consequences	
6	Consequences	Human Interaction	
		Competition	
7	Competition	Alternatives	
8	Science-Fiction	Science-Fiction	

 Table 2. Emergent themes from condensed codes.

# 5. Discussion

Although a preliminary study, the results illustrate a wide appreciation for both the novelty and limitations of neurally-controlled devices as applied to business and society. The following describes the eight emergent themes with illustrative comments provided from respondents.

## **5.1 Advancements**

Most of the respondents expressed an appreciation for the swift advances being made with neurally-controlled devices especially in light of the complexity of the brain and our relatively little knowledge of it.

The power of the brain is one of the hardest things to understand and we now have the power to control a small portion of it. Just to see what we have now and how the computer can sense, truly remarkable. (Student 1) There was a fierce optimism expressed by some for the future of the technology. Students appreciated the current state of the field and what might be possible.

*The science behind this innovative technology is nothing short of impressive. (Student 7)* 

#### 5.2 Limitations

Students demonstrated sufficient knowledge from the survey course on IS to appreciate the technical limitations of the device demonstrated and likely bugs. These concerns may be extended to other future neurally-controlled devices used in business as well as general systems.

I believe that there could be many glitches in the new nerve-tapping technology that allow voiceless phone calls to take place. I am a little skeptical when it comes to brand new technology because there are bugs that always need to be worked out. (Student 4)

As with other BCIs, there is a concern for such devices about speed...

Watching the video I noticed that the device seemed rather slow, for a moment I thought it wasn't going to work. (Student 12)

and reliability...

How does the computer distinguish the difference between inner thoughts and what you wish to communicate? (Student 15)

We are human and humans have emotions. Sometimes our emotions consume our thoughts so controlling our work equipment with our thoughts could be disastrous. (Student 20)

There was especially a concern about applicability to able-bodied persons, the majority of the workforce and society.

It is a very helpful device for people who are unable to speak and will help them to converse with others like everyone else does. I feel that it will be a little unnecessary for people who are able to speak, though. (Student 2)

## 5.3 Assistive Technology

Quite a few respondents saw advantageous uses as assistive technology for individuals with existing disabilities.

Devices like this are what help the disabled function with everyone else in this world in a convenient way. (Student 8)

[Bio-technology] actually lets disabled people live their lives almost fully, or at least be less of an obstacle for other people. (Student 9)

Others saw uses for individuals with situational disabilities.

Just a few weeks ago a teenage patient came to the operating room at [the local hospital] that had a chronic medical history. Some of these medical conditions have essentially trapped him in his own body. I would love to have seen a technology like this used for his benefit. (Student 7)

# **5.4 General Applications**

In addition to aiding individuals with disabilities, respondents envisioned applications in business for devices using neural input for communication.

I think that this technology will speed up business tremendously. For example, in a meeting for a new product, with many different buyers, buyers can race to purchase the product. They can be faster at purchasing these products by making a phone call during the meeting through their mind (thoughts)! (Student 18)

...in business you would be able to discuss decisions with one or more people in the room without letting other people the room privy to your conversation. (Student 15)

Further, there were applications for medicine as breakthrough technology for rehabilitation.

This can open many new doors in the medical industry. This can possibly help find a way to reroute nerves and possibly help paralyzed people by studying their brain actions. (Student 5)

## 5.5 Security

Despite the breakthroughs envisioned, more than one respondent expressed concerns for security and the prospects for hacking truly sensitive data: your thoughts.

...what's not to say later down the road they have hackers for this device that can tap into your thoughts; Just like hackers for your computer. (Student 16)

Indeed, there is a tradeoff with such advanced technology between the conveniences it affords and its misuse.

That would be amazing if they came out into the open market, but I can see so many issues with that. Hackers - Cheating in school- Voice recognition etc...I wonder though, how long will it be before it can copy our voices. (Student 14)

## 5.6 Fear of Unintended Consequences

Respondents felt there were consequences not yet realized by introducing neurally-controlled devices into mainstream society. This feeling of the unknown elicited a sense of fear and danger in some.

Same time I feel like this could be dangerous. Though they have not come out with an item that can just read your thoughts I feel like they soon will be able to. And that's a scary thought... All in all I think the whole idea is fantastic as long as it is used for a good purpose. (Student 12)

Others impressed the need to retain traditional modes of interaction lest we lose them.

Just because we have all of this amazing technology for communication does not mean that we should lose touch with the way people have been communicating for thousands of years. (Student 13)

I truly think that this amazing technology may hurt people who don't need to use it because it may decrease the human one to one interaction and use the natural human function like the mouth for talking. (Student 11)

## 5.7 Competition

Despite the advanced technology discussed, respondents appreciated that competitive devices already existed and companies wishing to operate in this space would face similar challenges as other organizations to maintain market share.

Companies that invest in creating new technology are constantly having to make improvements and updates to keep ahead of competitors. Ambient is already planning on releasing a newer version of the neckband this year that will use the internet and all of the references that it contains to search for phonemes. (Student 4)

#### 5.8 Science-Fiction

Although the use of neurophysiological tools for communication and control has been around for well over a decade, many still believe that this is all still science-fiction and hard to conceptualize. The notion of the technology being part of a movie fantasy is distinguished from the appreciation of technological advancements. Here this theme is characterized as being a more surreal, emotional expression whereas the other an appreciative, but more realistic grasp of our technical capabilities.

The advanced technology that we have working today seems so SciFi. Just fifteen years ago, people were amazed at the fact that we can have desktop computers at home. (Student 6)

This device seems like it belongs in movies and not in real life. I personally think it is a genius idea and I'm shocked that someone actually invented this thing! (Student 2)

## 6. Conclusions

This is a preliminary study on how business students view the applicability of neurally-controlled devices in their future workplaces and society. With the first retreat on neuro-IS taking place in 2009 with many of the IS field's senior scholars, there was a parallel discussion taking place in the classroom with aspirants to the organizations we wish to impact.

Although all respondents were from one institution, the university has a breadth of traditional and non-traditional students reflected in the age range of participants. In addition, participating students were exposed to the topic of neurophysiological tools, BCIs, and IS research by their instructor who specializes in these areas. Thus, respondents may have been biased towards positive responses by the instructor's personal enthusiasm previously evidenced in lectures. Grading was dependent on the quality of responses and supports made for viewpoints not the opinions themselves.

Overall, this work provides encouragement for researchers and developers to utilize perspectives from our students to help guide future efforts and increase the relevance of the sub-field of neuro-IS to practice. Our future contributors are hopeful of the technology for business, medical, and disability applications, but that hope is tempered by skepticism about the technical limitations and concerns for misuse in society. It will be up to us to adequately address these concerns.

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