

An Expert System for Matching Individual Characteristics and Features of Brain-Computer Interface Technologies with Performance

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Background

Research in the field of brain-computer interfaces is growing exponentially and even reaching such lesser-known areas of the United States like Kennesaw, Georgia thanks to researchers who continue to pursue ways to improve the quality of life for individuals with severe motor disabilities. This is my first year as an Assistant Professor at Kennesaw State University (KSU) located in Kennesaw, Georgia which is primarily an undergraduate institution but also seeing tremendous growth of their student population and scholarly activities. I was hired into the area of Business Information Systems with the expectations that I would start a “BrainLab” at KSU and continue my work of five years that I started in 2002 when I began my doctoral program at Georgia State University (GSU).

At GSU, I worked under the guidance of Dr. Melody Moore Jackson, founder and director of the first BrainLabs which are committed to developing real-world applications controlled by brain-computer interface technologies. During my doctoral program, I had the opportunity to attend the second and third *International Meetings on Brain-Computer Interface Technology* organized by the Wadsworth Center in New York which brought together some of the foremost minds in the field to share ideas and strategies for the future of the field. In addition, I was able to work with Dr. Brendan Allison while he completed his post-doc with the GSU BrainLab, and I participated in Dr. Moore Jackson’s success in establishing the second BrainLab at the Georgia Institute of Technology. Now, I am excited to have completed my apprenticeship and don the title as director of the third official BrainLab so that I may continue this exciting work with brain-computer interfaces at KSU.

The BrainLab at KSU is expanding upon the original BrainLab mission by exploring applications that may be used in mainstream, organizational settings, as well as for individuals who may experience being “locked-in” to their bodies. In particular, I am extending my dissertation work about understanding individual characteristics for control of brain-computer interface systems. This work seeks to serve as a foundation for evaluating and significantly improving the design of brain-computer interface systems. An important step in aiding the field is making the field aware of relevant work through publication and participation in such venues as SIGCHI and the workshop for “Brain-Computer Interfaces for HCI and Games.” The following describes in more detail my work in the area of system design and evaluation that I hope to share with my colleagues at the workshop.

Research Position

Brain-computer interfaces may be used for non-muscularly controlled computer applications [1, 2] and can therefore be considered assistive technology. Brain-computer interface technology

has been demonstrated in assistive technologies generally targeting users with severe motor disabilities as a result of disease, illness, or injury (e.g., Amyotrophic Lateral Sclerosis [ALS] or Lou Gehrig's disease or spinal cord injury) and able-bodied users with physical disabilities temporarily induced by their environment, such as with jet pilots subjected to extreme forces or soldiers in hostile territory. Brain-computer interfaces provide these users with capabilities for communication and control of environmental, navigational, and prosthetic devices. As a result, people who might not otherwise have an outlet can interact with their friends and family members and take more proactive roles in their environment. Thus, severely disabled users who are able to control brain-computer interface technologies can experience a significant improvement in their quality of life [3]. However, everyone does not experience equal success with controlling this technology; where someone is able to control a particular brain-computer interface technology with great reliability, another cannot control it at all. The match between an individual and technology is an *individual-technology fit* and can be reflected by the individual's performance with the technology.

More people would be able to effectively utilize brain-computer interface technologies if we understood more about the factors that affect performance with these systems. Currently, there exists a disparity in goals among researchers and assistive technology practitioners investigating brain-computer interfaces. Researchers tend to focus more on characteristics of the technology being developed and practitioners focus more on characteristics of the user. The result is that available brain-computer interface technologies are often matched to users through trial-and-error based on the specialized knowledge of the attending team. Unfortunately this unsystematic approach can waste valuable time and resources as users sometimes have diminishing abilities or suffer from terminal illnesses which preclude them from enjoying the full benefits of the provided system. A methodology that explains performance with available brain-computer interface technologies based on individual characteristics can greatly expedite the technology-fit process.

This work examines an important consideration for brain-computer interface design: describing characteristics of an individual user and his or her fit with a specific technology. *Characteristics* are a person's demographic, physiological, and cognitive traits. Individuals vary in their characteristics across many dimensions. It is necessary to develop paradigms and heuristics that link individual characteristics to available technologies to determine which approach is likely to be most effective. Then, assistive technology practitioners may better incorporate information about their users to refine their design efforts, and research teams may refer these users to other targeted groups specializing in the most appropriate technology. With better means for explaining performance with various biometric interface technologies, we make better use of the time and resources expended in offering impactful solutions to a sensitive user population. Further, we help advance the field of brain-computer interface technology for mainstream use by able-bodied persons by understanding the overall concept of individual-technology fit.

There are models and processes in existence for matching people with various technologies but these models have not yet been applied to the more non-traditional technology associated with brain-computer interfaces. In addition, these models are not intended to uncover the salient user characteristics necessary for an effective pairing with various brain-computer interface technologies. Therefore, I introduce a new individual-technology fit (ITF) framework that

explains performance with brain-computer interface technologies based on individual characteristics as illustrated in Figure 1.

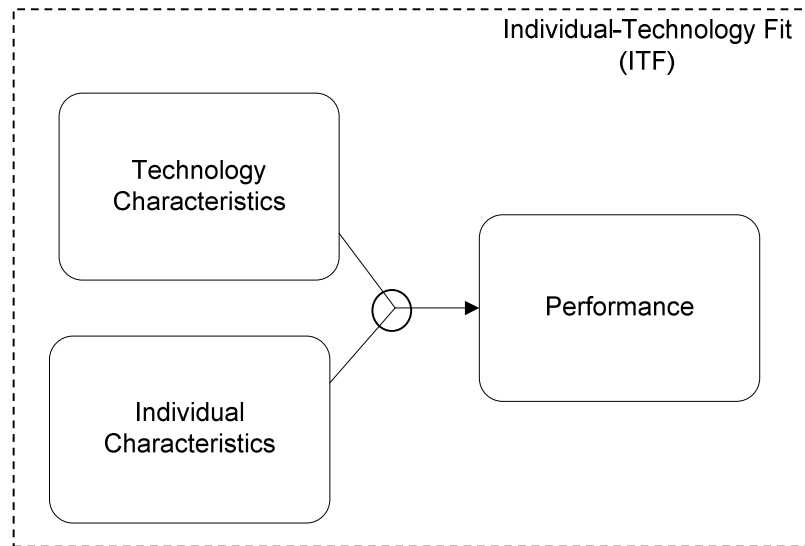


Figure 1. Framework of individual-technology fit

In this model, the technology features of brain-computer interfaces are based on a published taxonomy and attributes of a transducer [1]. Individual characteristics are captured using an approach for deriving comprehensive user profiles that may be used to explain individuals’ performance with brain-computer interface technologies. Performance is measured by *BioGauges* [4], a methodology and toolset for objectively measuring user controllability of brain-computer interface technologies.

To-date, twenty-eight (28) demographic, physiological, and cognitive individual characteristics ranging from sex to video game experience have been identified and tested through initial exploratory work with 5 ALS patients and 33 able-bodied persons. Three characteristics have been seen to be significantly related to fNIR control: age, regular caffeine consumption, and years of education, and are illustrated in Table 1.

Table 1. Brain-Computer Interface Technology Checklist illustrated for fNIR

No.	Individual Characteristic	fNIR-ITF
1.	The person is under the age of 64	✓
2.	The person is 65 years or older	x
3.	The person does not regularly consume caffeine	✓
4.	The person does regularly consume caffeine	x
5.	The person completed high school	✓
6.	The person did not complete high school	x

The brain-computer interface field could benefit from an expert system derived from this and further work that examines the salient characteristics for control of various brain-computer interface technologies. The system may be offered as a web-enabled application to allow

dynamically updated prediction algorithms. Researchers in the field could help validate current predictions and increase the reliability of future predictions by providing feedback from their own work. For example, a researcher may log on to the system, input the user profile, characteristics of the brain-computer interface system being used, and generate an initial prediction and reliability rating based on existing data. Once the researcher performs the experiment and observes the user's control of the particular system, the results could be input back into the expert system and incorporated into future predictions. The knowledge captured within this system would not be limited by time or space or researcher expertise because everyone would be able to contribute to a shared body of knowledge.

References

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