# Designing AAC Interfaces for Commercial Brain-Computer Interaction Gaming Hardware

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### Problem and Motivation

Our research is aimed at developing technologies for people with disabilities. Many people have disabilities that impede their ability to use typical input devices for computers. As computers have become more and more prevalent in everyday life this becomes more and more of an issue. By developing new input methods that allows for interaction with a computer, these people are given more independence. These methods can vary greatly. Some are simple interfaces that map a single large physical button to more than one letter either through scanning or some other software level interface. With recent advances in hardware, many alternatives to typical buttons have been developed.

One such of these is direct brain-computer interaction. These technologies not only can be added on to many existing physical buttons to provide more discrete inputs, but also open computer interaction to an entire group of people whose disabilities prevent them from using even a single button interface, such as people suffering from locked in syndrome (a disability in which mental faculties are maintained but spinal injury or brain damage prevents use of one's body). The biggest hurdle with brain-computer technology is the invasive nature of many early forms of the technology and the high cost of the technology. Our approach is to use a new device put out by the OCZ gaming peripheral company, the Neural Impulse Actuator, which is based on a more expensive non-invasive brain-computer device.

### Background and Previous Work

Augmentative and Alternative Communication devices are used to help people with physical and speech impairments to communicate effectively [3]. These devices can be adapted to allow those with these impairments to effectively use computers. Recent developments in brain computer devices have opened up possibilities for integrating this technology into AAC. There are two major types of brain computer devices that have been used with disabled users: invasive devices that use signals directly from the brain and passive devices [4, 7, 8, 9]. The EEG devices are of more interest to us as they require less risk to the user and do not have the cost of the medical procedures required to implant the more invasive technologies. One of the major advances in the area of EEG based devices was the Brain Finger program and device developed by Brain Actuated Technologies (BAT)[1]. BAT's device is a headband that reads brain signals to muscles in the facial region. They have not only used their device with AAC users but have also shown that training can lead to effective use of Brain Fingers with existing AAC software [2]. A device put out by the OCZ Company, the Neural Impulse Actuator (NIA), is a budget version of this headband designed for gaming. In addition to its marketed purpose, it also can be used as an affordable alternative to expensive brain computer devices [6]. This lead us to trying to create a fully implemented interface designed around the NIA.

### Uniqueness of Approach

The two largest hurdles to the use of brain-computer hardware are the invasive nature of many of the devices and the cost of many of the devices. Recently, the gaming accessory and memory company OCZ released a brain-computer device as a peripheral for use with popular computer games, the Neural Impulse Actuator (NIA). The device retails from anywhere to $40 to $120. This stands as a much less expensive price point when compared to the $2000 price point of the device it is derived from, the Brain Fingers device by Brain Actuated Technologies.

Our proposal was to attempt to use this inexpensive device as an alternative to the more expensive technologies, thus making brain-computer technology and affordable option for people with disabilities that inhibit their use of the computer. Due to the less expensive nature of the device we predicted that it would have certain weaknesses when compared to its pricier counterparts. Based on this prediction we chose to design a typing level interface specifically designed for use with the NIA. By taking this approach, we could compensate for any weaknesses within the interface itself.

Our plan for development and testing was as followed: general testing, initial interface design, informal testing, formal testing, and refinement. During the general testing phase we planned to acquire the device and determine if it met the description OCZ provided. We then planned on designing a first iteration of an interface for it, taking into account any weaknesses discovered during our initial testing. Then the interface would be tested and used by the members of the research team on an informal level. After this informal testing, formal tests would be set up with traditional users, most likely college students who volunteer via word of mouth. Finally, based on the results of these formal tests the interface would be further refined and then tested with people with disabilities.

**Results and Future Work**

*General Testing*

During the first stage of our research we decided to test the basic functionality of the Neural Impulse Actuator (NIA) by using exactly as it is marketed, as a gaming peripheral. The NIA uses a software interface that allows the binding of certain facial gestures to be mapped to switches. These switches in turn can be assigned to keystrokes. This is all done via the Brain Fingers software interface developed by Brain Actuated Technologies (BAT). The NIA comes with a number of predefined sets of the switches designed for specific computer games.

We decided on using the NIA's presets with the game Half-life 2 by Valve. During this process we were looking for certain things: which gestures were most reliable, which could be easily executed and learned by a user, and were there any general difficulties with using the device. The first weakness we discovered with the NIA was that the device was vulnerable to interference. However, this vulnerability was greatly reduced by the grounding of the user.

After using the NIA for a while with the game we found there were three reliably read and easily learned gestures: left glance, right glance, and general facial tension. Left and right glance are triggered by the user glancing to the left or the right. We found that initially it could be difficult to not glance back the other way while the user is returning their eyes to center, however this diminished with user training and more precise sensitivity calibration of the device. Muscle tension is a switch triggered by the tensing of the muscles in the face. Various keystrokes can be mapped to different levels of tension. However, in order to maintain learn-ability and distinction between gestures we chose to only map one keystroke to general muscle tension. This eliminates the need to be able to precisely control the muscles of the face, an ability that can vary greatly between users.

*Interface Design*

When designing our interface for the NIA we wanted to base it on an existing AAC interface style. By doing so we reduced the need to learn a brand new visual interface. We started with a row-column style interface as this would allow for the most flexibility with the mapping of the three buttons we had determined we would use. In our interface characters are arranged in a square grid based on usage rating. The more commonly used letters are located near where the users cursor begins and as distance from the starting point increases the usage rating of the characters decrease. We based our usage rating on an analysis of character frequency in documents found on Google [10]. After a user selects a character it is added to the end of the current word. When a space is selected the current word is then added to the paragraph section of the window located below the grid. A backspace character, located directly under the starting position in the grid, is selected to delete a character off the current word, or if the current word is empty, to bring back the previous word. Upon the programs exit the paragraph text is saved as a .txt file. The file can be named using the interface.

When designing the interface we designed three different navigation schemes: a 2 button sequential version, a three button sequential version, and a three button roaming version. The 2 button navigation scheme uses only the glances to navigate the grid. Glancing to the left cause the selector to move over a column until the user is in the proper column. The right glance is used to select the column. Once the proper column is selected the same scheme is used to select the proper character in the column. We included this two button scheme because there are cases of people maintaining only eye movement due to an accident and this would allow them use of the device to communicate.

The three button sequential scheme is nearly identical to the 2 button scheme, however the left and right glance are used to move back and forth among the columns and muscle tension is used to select. This is then repeated for the characters within the selected column. In the three button roaming scheme, left glance cycles through the column and right glance cycles through the rows. Once the proper character is selected at the intersection then muscle tension is used to select.

*Informal Testing*

Once the interface was designed we began informally testing it among those directly working with the device. We each took sometime to try to get used to using the grid interface and train in depth with each of the different switches. Upon training with the grid we found that adding an adjustable delay into the interface helped decrease the frustration of the learning process. By adding a short pause period after each input from the NIA the user is able to take time to return to a relaxed, eyes center position. By slowly decreasing the delay the user can slowly increase their speed and precision as they get used to returning to the relaxed position.

*Future Plans for Formal testing and refinement*

We have formulated a procedure for training people with the device. Our plan for testing the feasibility of this program is to recruit people by word of mouth in order to gauge the effectiveness of the training and the reaction to using the device. In order to measure the effectiveness of the training we have built in a logging program into the interface. This program allows us to log all keystrokes inputted with the NIA. We can then use these to calculate the amount and types of errors made and the typing speed over the course of a session. We have planned two different programs: a single session and a multi-session training program. The single session and the first session of the multi-session program are identical. It is an hour to two hour session in which we take them through training with the NIA along with a growing grid. After this first session they will be asked to fill out a brief survey designed to get feedback on the fatigue experienced while suing the device as well as their thoughts on the training process and any other feedback. Participants in the multi-session are brought back for two or three more half-hour to hour sessions over the next two weeks. This allows us to measure retention of skill with the NIA.

After formal testing with traditional users we will use our results to further refine the interface and training routine. After this stage of refinement and analysis we will move onto to running tests with some users with disabilities that inhibit use of a typical input device. In addition plans for adding features to the final version of the interface are currently being worked on. One such feature that has already been added is the ability to send the created text file as an email from within the interface. Eventually, full OS integration is proposed. This would turn the interface into an onscreen keyboard designed for use with the NIA.

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