Inclusive Design for Brain Body Interfaces

Paul Gnanayutham¹ and Jennifer George²

¹ Department of Computing, University of Portsmouth, Buckingham Building, Lion Terrace, Portsmouth, PO1 3HE, United Kingdom
² SAE Institute, United House, North Road, London, N7 9DP, United Kingdom
paul.gnanayutham@port.ac.uk, jennifer.george@sae.edu

Abstract. In comparison to all types of injury, those to the brain are among the most likely to result in death or permanent disability. A certain percentage of these brain-injured people cannot communicate, recreate, or control their environment due to severe motor impairment. This group of individuals with severe head injury has received little from assistive technology. Brain computer interfaces have opened up a spectrum of assistive technologies, which are particularly appropriate for people with traumatic brain-injury, especially those who suffer from “locked-in” syndrome. Previous research in this area developed brain body interfaces so that this group of brain-injured people can communicate, recreate and launch applications communicate using computers despite the severity of their brain injury, except for visually impaired and comatose participants. This paper reports on an exploratory investigation carried out with visually impaired using facial muscles or electromyography (EMG) to communicate using brain body interfaces.

Keywords: Brain-Body Interface, Inclusive design, Neuro-rehabilitation, Assistive Technology and visual impairment, EEG, EMG and EOG.

1 Introduction

As medical technology not only extends our natural life span but also leads to increased survival from illness and accidents, the number of people with disabilities is constantly increasing. World Health Organization [1] estimates that there are more than 600 million people who are disabled as a consequence of mental, physical or sensory impairment thus creating one of the world’s largest minorities. It has been estimated that 80 to 120 million European citizens have some form of disability, exceeding the population of almost every European state [2] In comparison to different types of injury, those to the brain are among the most likely to result in death or permanent disability. In the European Union, brain injury accounts for one million hospital admissions per year. A certain percentage of these brain-injured people cannot communicate, recreate, or control their environment due to severe motor impairment. This group of severely head injured people is cared for by nursing homes that cater for their wellbeing in every possible way. Their loved ones also play a major role in the wellbeing of this group of people.
1.1 Brain Injury

There are two stages in traumatic brain injury, the primary and the secondary. The secondary brain injury occurs as a response to the primary injury. In other words, primary brain injury is caused initially by trauma amyotrophic lateral sclerosis, brain stem stroke etc., but includes the complications, which can follow, such as damage caused by lack of oxygen, and rising pressure and swelling in the brain. A brain injury can be seen as a chain of events beginning with the first injury which occurs in seconds after the accident and being made worse by a second injury which happens in minutes and hours after this, depending on when skilled medical intervention occurs. There are three types of primary brain injury - closed, open and crush. Closed head injuries are the most common type, and are so called because no break of the skin or open wound is visible. Open head injuries are not so common. In this type of injury the skull is opened and the brain exposed and damaged. In crush injuries the head might be caught between two hard objects. This is the least common type of injury, and often damages the base of the skull and nerves of the brain stem rather than the brain itself. Individuals with brain injury require frequent assessments and diagnostic tests [3]. Most hospitals use the Glasgow Coma Scale for predicting early outcome from a head injury, for example, whether the person will survive or Rancho Levels of Cognitive Functioning for predicting later outcomes of head injuries [4].

1.2 Brain Body Interface Devices

The brain is the centre of the central nervous system in humans as well as the primary control centre for the peripheral nervous system (Fig.1.). The building blocks of the brain are special cells called neurons. The human brain has approximately hundred billion neurons. Neurons are the brain cells responsible for storing and transmitting information from a brain cell. The adult brain weighs three pounds and is suspended in cerebrospinal fluid. This fluid protects the brain from shock. The brain is also protected by a set of bones called the cranium or a skull.

The three main components of the brain are the cerebellum, cerebrum and brainstem. The cerebellum is located between the brainstem and the cerebrum. The cerebellum controls facial muscle co-ordination and damage to this area affects the ability to control facial muscles thus affecting signals (eye movements and muscle movements) needed by Brain-Body Interfaces. The cranial nerves that carry the signals to control facial movements also originate in the brainstem, hence the brainstem is of interest when using Brain-Body Interfaces.

Assistive devices are essential for enhancing quality of life for individuals with severe disabilities such as quadriplegia, amyotrophic lateral sclerosis (ALS), commonly referred to as Lou Gehrig’s disease or brainstem strokes or traumatic brain injuries (TBIs). Research has been carried out on the brain’s electrical activities since 1925 [5]. Brain-computer interfaces (BCIs), also called brain-body interfaces or brain-machine interfaces provide new augmentative communications channels for those with severe motor impairments. In 1995 there were no more than six active brain computer interface research groups, in 2000 there were more than twenty and now more than thirty laboratories are actively researching in BCI [6]. A BCI is a communication system that does not depend on the brain’s normal output pathways