Neural Substrates of Navigation with Brain Computer Interference

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Abstract*—Navigation in time-evolving environments with moving targets and obstacles requires cognitive abilities widely demonstrated by even simplest animals. Nevertheless, it is a long-standing challenging problem for artificial agents. Research on navigation has been particularly notable for the increased understanding of the factors affecting human navigation and the neural networks supporting it. The use of virtual reality environments has made it possible to explore the effect of environment layout and content on way-finding performance.

Keywords - Navigation, Brain, Computer Interface, Cognitive.

I. INTRODUCTION

The study of navigation has a long history in neuroscience. At one time or another we have each become lost—maybe in a new city, heading in the wrong direction or walking in circles on the way to the hotel. In contrast, most of us can travel to and from work each day without any problems, often arriving with little recollection of the journey we took and the decisions we made along the way. Remembering and navigating environments is of great importance for humans and animals alike, yet we often take it for granted.

II. BRAIN-COMPUTER INTERFACE

A BCI has an input (e.g.electrophysiological activity from the user), an output (i.e. device commands), components that translate input into output and a protocol that determines the onset, offset, and timing of operation. Signals from the brain are acquired by electrodes on the scalp or in the head and processed to extract specific signal features (e.g. amplitudes of evoked potentials or sensory-motor cortex rhythms, firing rates of cortical neurons) that reflect the user's intent. These features are translated into commands that operate a device (e.g. a simple word processing program, a wheelchair, or a neuroprosthesis).

III. NEURAL SUBSTRATES

The course of its investigation is marked by a number of key events, much work in the past year has gone into exploring further the neural basis of navigation in humans. Just as the layout, complexity and content of environments affect navigation performance and interact with the sex and age of subjects, so might environmental and subject factors interact with the neural mechanisms supporting navigation. Very little is yet known about the neuroanatomical differences, if any, that are associated with sex or age differences and human navigation. In contrast, the effects of environmental manipulations have been examined by functional imaging studies in which subjects navigate in virtual environments during PET or fMRI scanning. Neuroimaging provides unique insights into the networks of brain regions supporting navigation in the normal human brain *in vivo*. A consistent pattern of brain activity associated with navigation has emerged from imaging work in the past year or so, but there are still some disagreements about the exact functions of particular elements of the navigation system. From recent imaging work it seems clear that key regions for navigation in humans include the medial and right inferior parietal cortex, the posterior cingulate cortex, parts of the basal ganglia, the left prefrontal cortex, the bilateral medial temporal region .Using fMRI scanning, have reported that navigation in a virtual maze is associated with increased activity in the parahippocampal gyrus, giving rise to the suggestion that, unlike rats, the parahippocampal gyrus but not the hippocampus is the crucial neural structure supporting spatial mapping in humans . Other imaging studies, however this area is active when recalling landmarks, but not when recalling complex routes where the use of a cognitive map would be required. A PET study found that the parahippocampal gyrus is activated when the recall of object location in a spatial array is required, akin to traditional table-top tasks. Passive processing of scenes also activates this area. This evidence points to a role for the parahippocampalgyrus and posterior occipito-temporal cortex in object–location associations , but not more complex cognitive mapping. Further evidence of this comes from a PET study in which navigation in a stark featureless virtual maze-like environment was compared to navigation in a maze-like environment that included several everyday objects as landmarks. The parahippocampal gyrus was activated only when navigation occurred in the maze with landmarks. Thus, just as landmarks were found to have an impact on way-finding in the behavioural studies described above, their presence is also an influential factor on the neural mechanisms supporting navigation. The suggests that representing large-scale space depends on the human hippocampus proper, either directly, or at least via its role in episodic memory. The imaging work just described also highlights a further effect of environmental manipulation, with implications for the brain regions activated. In scanning studies using simple maze-like environments, there was no increased activation of the hippocampus proper. They do not feel realistic (i.e. they have poor ‘presence’), and they can be amenable to solution without recourse to a cognitive map (e.g. by using a linear or verbal representation). This stands in contrast to the increases in hippocampal activity observed when subjects learned how to navigate through a town by watching film footage of travel through a real town , by recalling routes through a real city, or by recalling a route learned in the real world before scanning took place . Taking these findings into consideration, scanning experiments are now using more realistic town-like environments to simulate real navigation with increased ‘presence’.

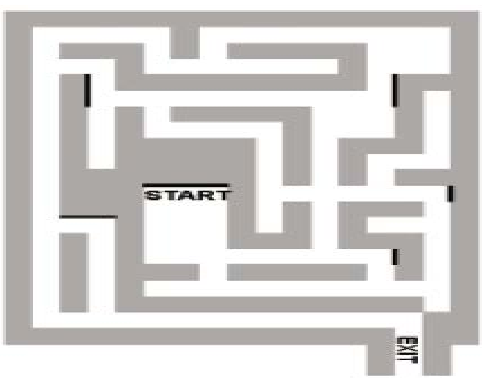

Fig. 1 Aerial view of the virtual environment of one maze demonstrating the possible intersections and paths (not shown to subjects). Landmarks with distinct patterns are indicated by solid black lines.

The opportunity afforded by being able to combine monitoring changes in blood flow with recording and measuring online navigation performance has given further insights into the precise activity of elements of the navigation network. Recently, used PET to scan subjects while they performed retrieval tasks in a complex computer-simulated town they had spent time learning prior to scanning. Subjects either found their way to specified destinations in the town using the internal representation they built up during learning or followed a trial of arrows through the town that did not require the use of topographical memory but controlled for movement and optical flow. Subjects’ behavioural performances as well as changes in cerebral perfusion during scanning were recorded and analysed. The right hippocampus was more activated when reaching a destination successfully than when following the trail of arrows, and during successful trials than during unsuccessful trials. In addition, there was a significant correlation between blood flow changes in the right hippocampus and right inferior parietal cortex with the accuracy of navigation—the more accurate the path taken to the goal place, the more active these regions. The highest correlation was found in the right hippocampus and the second highest in the right inferior parietal cortex.

Brain waves and EEG

Electrical recordings from the surface of the brain or even from the outer surface of the head demonstrate that there is continuous electrical activity in the brain. Both the intensity and the patterns of this electrical activity are determined by the level of excitation of different parts of the brain resulting from sleep, wakefulness, or brain diseases such as epilepsy or even psychoses.

The undulations in the recorded electrical potentials are called brain waves, and the entire record is called an EEG

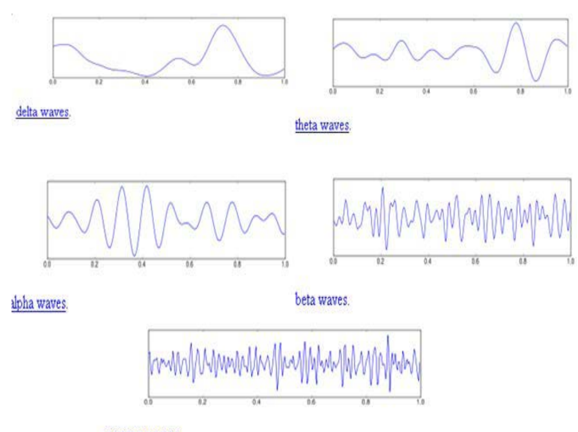

Fig 2.Delta waves(0.4-4 Hz), Theta waves (4-8 Hz) , Alpha waves (8-13 Hz), Beta waves(13-30 Hz) and Gamma waves (26-100 Hz) .

The mean and any linear trend in the data were removed before multiplying the signal with a window. Hamming window was used. Band Pass filter was used with 1Hz low cut off frequency and 35Hz high cut off frequency. The objective of filtering is to improve the quality of a signal. After acquiring the data, it is necessary to process the raw signal before it can be classified by the computer. First, the signal suffers a pre-processing, which consists mainly in filtering the signal [1]. Second, this signal is subjected to a feature extraction procedure, for example, spectral analysis or voltage amplitude measurements .

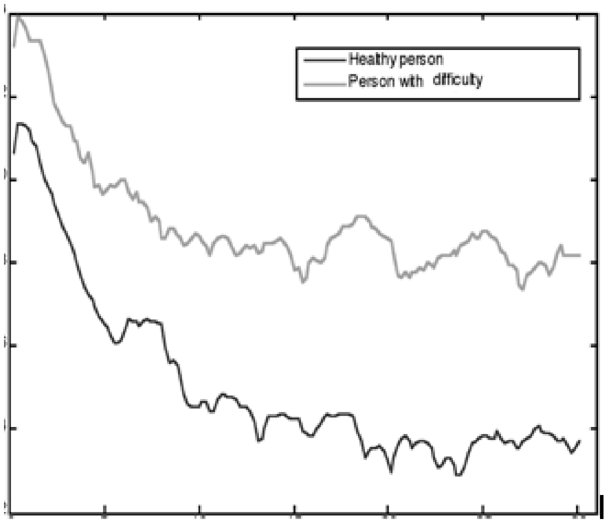

Fig 2. EEG signals from a healthy person and a person with difficulty

Through the feature extraction, we expect to be capable of recognising a specific activity from the user's brain. The procedure used must be able to discriminate which information is relevant and which is not. BCI system is the classification of the signal, in which it is necessary to create an algorithm which translates the signal features into orders recognisable by the computer.

IV. CONCLUSION

A brain–computer interface is a communication and control channel that does not depend on the brain's normal output pathways of peripheral nerves and muscles. The complexity and content of the environment affects navigation success and may also interact with the sex and age of the subjects being tested. The nature of the environment also impacts upon the neural mechanisms required to support navigation.

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