

Comparison: Unlocking the Locked-In by Eye Tracking System and Brain Computer Communication

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Abstract – In this study, I evaluated various systems that are available for the locked-in patients like eye tracking system for the rehabilitation of completely locked-in patient and brain computer communication-unlocking the locked-in. In the eye tracking systems for the rehabilitation of completely locked-in patient, MATLAB and JAVA-based interfaces were developed for providing an alternative way of communication to the locked-in patient who is aware and alert but who cannot communicate because of Locked-In Syndrome whereas in brain-computer communication in which the electrical activity of the brain are converted into signals which controls the external device.

Key Words: Locked-In, Cases of Locked-In, Eye Tracking System, BCI, Comparison

1. INTRODUCTION

There are three types of mind states of the patients:

1. Conscious Patient
2. Semi-conscious Patient
3. Un-conscious Patient

Conscious Patient: The consciousness is the state in which a person or the patient is awake, aware or alert in which most human being functions.

Semi-conscious Patient: The semi-consciousness is an impaired state of consciousness that is characterized by obtundation, stupor, hypersomnia, etc. The patient can recover only by electric stimulation. The semi-consciousness state is distinct from persistent vegetative state in which there is absence of responsiveness and awareness due to overwhelming dysfunction of the cerebral hemisphere, with sufficient sparing of the diencephalon and brain stem to preserve automatic and motor reflexes and sleep-wake cycles and locked-in syndrome in which patient who are awake and conscious but not able to produce speech, limb or facial movements. Locked-in patient is an immobile body but being conscious.

Un-conscious Patient: Un-conscious is the state in which the patient is not aware about everything that is about own self and about his/her surroundings. The un-conscious patient is even not able to respond to his/her surrounding. The causes for a person to be in an un-conscious state are the following: due to lack of oxygen to the brain, shocks, damage to the central nervous system due to drugs, injury, etc.

The Glasgow Coma Scale (GCS) was published by Graham Teasdale and Bryan J. Jennett in 1974 at the University of Glasgow's Institute of Neurological Sciences at the city's Southern General Hospital.

The consciousness of a person is described using Glasgow Coma Scale (GCS) after a brain injury: If the GCS is in between 3 to 8 then it is said to be severe. If the GCS is in between 9 to 12 then it is said to be moderate. And if the GCS is in between 13 to 15 then it is said to be mild.

Table-1: GCS for Eye Opening

Eye Opening(E)	
4	Spontaneous
3	To voice
2	To pain
1	None

Table-2: Eye Opening Response

When the patient opens eyes spontaneously then the GCS is 4.	When the patient opens eyes on calling by someone then the GCS is 3.	When the patient opens eyes on pain then the GCS is 2.	When the patient does not opens eyes then the GCS of the patient is 1.
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Table-3: GCS for Verbal Response

Verbal Response(V)	
5	Normal conversation
4	Disoriented
3	Words, but not coherent
2	No words, only sounds
1	None

Table-4: Verbal Response

When the patient responds verbally and the response is oriented then the GCS is 5.	When the patient responds verbally and the response is confused then the GCS is 4.	When the patient responds verbally and the words are inappropriate then the GCS is 3.	When the patient responds verbally and the sound is incomprehensible then the GCS is 2.	When the patient does not have any kind of verbal response then the GCS is 1.
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Table-5: GCS for Motor Response

Motor Response(M)	
6	Normal
5	Localized to pain
4	Withdraw to pain
3	Decorticate posture
2	Decerebrate
1	None

Table-6: Motor Response

When the patient obeys instructions then the GCS is 6.	When the patient's motor response is localized then the GCS is 5.	When the patient's motor response is withdrawing then the GCS is 4.	When the patient's motor response is abnormal flexion then the GCS is 3.	When the patient's motor response is extensor then the GCS is 2.	When the patient's motor response is nil then the GCS is 1.
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2. Coma Patients:

The locked-in syndrome was introduced in 1966. The locked-in patient is aware about their surrounding but can't respond to it just because of paralysis of voluntary movements. The other name of locked-in syndrome is cerebromedullary disconnection, de-efferented state or pseudo-coma. The locked-in patient's intellectual functions, memory, language and sensations are preserved. In complete locked-in syndrome, person loses even eye movements but they are conscious.

The causes of locked in syndrome is because of damage to Pons and also trauma. The others cause can be disease of circulatory system, brain stem stroke, snakebite, amyotrophic lateral sclerosis, etc.

The various systems have been developed to provide an alternative way of communication to locked-in patient who had lost communication ability.

The various cases of the locked-in patients:

1. **Julia Tavalaro:** Julia Tavalaro was 27-year old housewife and mother. In 1967, she suffered from multiple strokes which resulted into complete paralysis. She was concluded by the doctors as brain dead. In 1973, she was given physical therapy and an opportunity to communicate.
2. **Nick Chisholm:** Nick Chisholm was paralyzed due to the accident in 2000. According to him, it was the horrible and worst experience and it should not

happen to worst enemy. The words of the Nick Chisholm are the following:

“Words can’t describe the situation I have been left in-but this is as close as I can get it: an extremely horrific experience that I wouldn’t wish on my worst enemy.

When you’re like this (despite having 24 hour care) it’s an incredibly lonely existence at times. It’s amazing how much time I have to think about things now since the accident. There’s heaps of thoughts that I don’t bother even expressing.”

3. **Bob Veilette:** Bob Veilette was locked-in in 2006 due to stroke. He had no physical therapy or speech or occupational therapy due to financial problems. He was used to communicate using letter board held by an assistant. The size of his pupils was varying continuously so he was not able to use the brain computer interface.
4. **Catherine O’Leary:** Catherine O’Leary was 31-year-old, when she undergone a surgery to remove brain tumor and during that strokes left her completely paralyzed. She was used to communicate by blinking eyes-one blink for yes and double blinks for no.
5. **Jean-Dominique Bauby:** In 1995, Jean-Dominique Bauby suffered from massive stroke and he was having ability to blink his left eye. He died within less than 2years only.
6. **Gary Griffin:** Due to Lou Gehrig’s disease Gary Griffin was locked-in. He used Neuro-switch to control computer and used it for communication.
7. **Johnnie Ray:** In 1997, Johnny Ray suffered from a brain stem stroke which left him unable to move. Sensors were implanted in Ray’s brain which allows him to move a cursor on computer with his thoughts. For him, a hole was made on the skull and electrodes were placed in and the signal was captured.
8. **Erik Ramsey:** In 1999, 16-years old, Erik Ramsey suffered from a car wreck which caused him a stroke and left him locked-in. He was used to communicate by moving eye in up direction for saying yes and in down direction for saying no.

The various systems that help locked-in patients to communicate are:

2.1 Eye Tracking System for the rehabilitation of completely locked-in patient:

In this system, a Web camera was mounted on the head of the patient. The web camera captures real-time images of patient’s eye. The images which were captured using web camera were applied to MATLAB for computing coordinates of pupil position. After computing the position of pupil, a program sends a command to the interactive JAVA-based interface. The patient was provided a matrix of simple graph to understand called pictograms. As the pictogram was clicked or activated, the system plays audible statements. That statement is recorded in any language reflecting desired activity.

The main advantages of the system named “Eye Tracking System for the rehabilitation of completely locked-in patient” are the following:

- No huge setup is required.
- Low cost
- The patient can easily express their feelings and thoughts.
- Less time consuming
- Patient can communicate like a normal person.
- Easy to interface

2.2 Brain Computer Interface (BCI):

Brain computer interface is a system in which a person can control his/her computer without any kind of movement. The signal is acquired from the brain and the signal processing is done and at last commands are given to the BCI application.

BCI’s are widely used for communication purpose for the various patients like locked-in patient who can express his feelings easily. BCI’s are also used for computer access or controlling of devices. It is used for rehabilitation to regain motor skills which are lost due to stroke.

There are two types of BCI:

1. Invasive BCI and
2. Non-Invasive BCI

In invasive BCI, the electrodes are implanted on the surface of brain surgically, whereas in non-invasive BCI, the electrodes are placed on the scalp. The non-invasive BCI does not require any surgery for the placement of electrodes.

The electrodes which are placed on the surface of brain or scalp are used to capture brain signals.

The signals which are captured by the electrodes are applied to the computer. The computer uses various software for converting that brain signals into computer commands. The various computer commands are applied according to the brain signal. The interface provides a direct communication between brain and the object to be controlled.

In June 2006, Peter Brunner, an American scientist at the European Research and Innovation Exhibition in Paris developed a message by focusing or concentrating on display for that number of electrodes (cap fitted electrodes) were utilized. The Brunner's brain activity was captured by the electrodes and it was applied to computer and the specific letters are selected using appropriate software. The BCI Brunner demonstrated is based on a method called the Wadsworth system. The Wadsworth system uses adaptive algorithm and pattern-matching techniques to facilitate communication. The scientist, who was not able to move even his eyes, sent the following email message:

"I am a neuroscientist WHO (SIC) couldn't work without BCI. I am writing this with my EEG courtesy of the Wadsworth Center Brain Computer Interface Research Program."

The various reasons that developed the brain computer communication:

- The patients (locked-in) were not able to express their feelings as well as thoughts.
- Huge setup.
- EEG is limited to electrically active neuronal elements.
- Complexity of the system.
- EEG based system were very expensive.
- Limited communication system capacity.

The limitations of brain computer interfaces are the following:

Habituations: It is being tolerant and dependent on something that is psychologically or physically abnormal.

Impaired Visual System: Total blindness is the inability to tell light from dark, or the total inability to see. The

impairments of vision and less vision is a severe reduction in vision that cannot be corrected with standard glasses or contact lenses and reduces a person's ability to functions at certain or all tasks.

Interference and Distraction: Both arise during the use of Brain-Computer Interface when used for communication by the user.

Instable EEG frequency bands: EEG frequency bands are instable for cognitive tasks.

Invasive recording: Invasive recording is used for collecting data from the brain.

2.3 Brain Computer Communication Unlocking the Locked-In:

In this brain computer communication, the different between direct and immediate recognition of brain signals is used. The brain signals are taken continuously from the brain and the detected signal has specific power spectra.

According to the sensory feedback, the control of the EEG response is taken. The control of the EEG response can be taken based on the positive reinforcement of correct behavior. In this, there is a direct connection for communication between the brain and a computer. Due to continuous feedback, certain level of EEG signal is generated or developed. This may reflect in the movement of a graphic symbol on a monitor toward a target or in sounds whose frequencies vary according to the amplitude of brain response.

The advantages of this system are the following:

- High accuracy
- Rapid
- Feasible
- Reliable
- Efficient
- Easy to carry
- Direct communication between brain and computer

The disadvantages of this system are the following:

- Noises may affect the communication system.
- Accuracy is required in order to avoid unwanted communication.
- Proper speed between muscle-controlled devices and EEG-controlled responses.

- Output channels are required to be considered for specific situations.

3. CONCLUSIONS

The Eye Tracking System for the rehabilitation of completely locked-in patient provides the advantages of low cost, low processing power, ease of operation, little training requirement, minimal disturbance to patient, ease of customization to any mother tongue. The advantages of the brain computer communication are they are rapid in operation, they are having high accuracy and they are feasible. The disadvantages that are offered by the brain computer communication are accuracy is required in order to avoid unwanted communication, proper speed between muscle-controlled devices and EEG-controlled response and the output channels are required to be considered for specific situations.

ACKNOWLEDGEMENT

The author is grateful to Mr. Mayur Chovatiya and Prof. Nirmal Bhatt for the help and support.

REFERENCES

- [1] Eight Cases of Locked-In Syndrome at <http://mentalfloss.com/article/19813/eight-stories-locked-syndrome>
- [2] Glasgow coma scale at <http://www.brainline.org/content/2010/10/what-is-the-glasgow-coma-scale>.
- [3] Coma Patients Causes at <http://www.healthcommunities.com/coma/symptom.s.html>.
- [4] Coma <http://www.nhs.uk/Conditions/coma/Pages/Introduction.aspx>
- [5] Glasgow Coma scale at <http://www.medicinenet.com/coma/article.htm>
- [6] Brain computer communication <http://www.gizmag.com/brain-computer-interface-brain-stroke-communicate/34204/>
- [7] BCI for locked-in patient at <http://www.npr.org/2014/10/26/359081510/electrode-cap-helped-locked-in-patient-get-his-thoughts-out>
- [8] Types of BCI at <http://www.alsa.org/als-care/resources/publications-videos/factsheets/brain-computer-interface.html?referrer=https://www.google.co.in/>

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