Original Article

A smart healthcare system for measuring and monitoring psychophysiological parameters in humans

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Abstract

Evaluation of psychophysiological parameters of human can benefit doctors and physicians to make effective treatment. In this research, a specialized framework for assessing key psychophysiological factors has been delivered. The psychophysiological data was collected from nine persons. In present study, the key psychophysiological parameters such as meditation and attention level of participants have been evaluated using EEG-based brain-sensor. In addition, a pulse sensor was used for measuring live heartbeats. The results suggest that pulse rate sensor and the EEG sensor can act as efficient interface to assess human's psychophysiological parameters.

Keywords: Psychophysiological parameters; emotional problems in adults.

INTRODUCTION

Analyzing psychophysiological status can be beneficial to explore one's perception of adaptive behavior and mental state. Recently, more spot-light has started on emotion recognition via the EEG sensors. Identification of complex emotions is rendered simpler with the advent of the Internet of Things (IoT) that provides different forms of EEG sensors. EEG based devices like sensors are useful in recording the subject's brain behaviors. Our brain is made up of cells network of neurons that provide the base of the central nervous. These nerves are important for the treatment and delivery of electrical impulses. These neurons remain closely entangled with synapses that serve as a medium for seeing or impeding any behavior. This generates a very minor electrical signal by utilizing a neuron. This also produces a much amplified magnetic current in such a way that it could be measured by our headshell, bones, and muscles. The amplified electric field would be controlled and recorded using an EEG device.

This helps them catch easier, so they are tested. This electric current is usually referred to as brain impulses. So we use an IoT system to catch and perceive the brainwaves produced against the sensory input. For example, an investigation was performed to assess and monitor emotional changes in a person using EEG-based sensor against visual stimuli [3]. EEG sensors grab complicated emotional interactions through brainwave signals. Previous researchers made clear that humans have anxiety issues, which leads to a weak regulation of emotions when the situation is demanding [3]. Emotional issues may be disruptive in their everyday lives. The process of detecting emotions not only assists in understanding dominant emotions in the brain of subjects, but also provides understand about their mental state.

Exploring their mental health can aid during speech therapy, and without the knowledge of emotional condition, the result of the therapy may be unsuccessful [2].

On the other side, assessing heart rate of targeted subjects has become easy due to the emergence of various IoT based on low-cost pulse sensors. The IoT has a key role to play in simplifying daily work and jobs. IoT provides several opportunities in the area of healthcare. A variety of sensors are used to relieve other everyday activities [3]. For instance, Pi-camera may be used to track the falling activities of elderly people[4]. Among the sensors, non - intrusive EEG-oriented sensors are specially used for measuring one's emotions [2], [5]. Authors in [7] constructed and introduced as sleep tracking systems utilizing three forms of radio frequency sensors. The 3 kinds of RF detectors for heartbeat monitoring on the forearm are a customizable single reflector RF, series resonators, and an implant-locked PLL oscillator sensor. They found that the heartbeat decreased dramatically after sleep onset relative to before sleep. Besides, the RF device may be used as a contactless noninvasive tool to calculate heartbeat while sleep. The study is done using a sensor along with a fundamental differential sequence variance algorithm, which may show the rate of pulse transition. Then the sorting process is used to correctly obtain the pulse duration.

Their exploratory comparisons and investigates suggest that the sensor with this algorithm retains a more productive way of screening unsorted signals, mainly by improving the efficiency of complex pulse recognition [7]. The regular blood pressure (BP) measurement device was used to measure the rate of association. The diastolic blood pressure is determined based on predefined. The PPG pulse is used to track blood PB pulsations in the finger to reach maximum systolic to diastolic pressure sensitivity. They concluded that the optimized PPG-based procedure would be used as a non - intrusive solution to traditional prosecutions-cuff methods in long-term and constant blood pressure control, pulse rate, and pulmonary function [8].

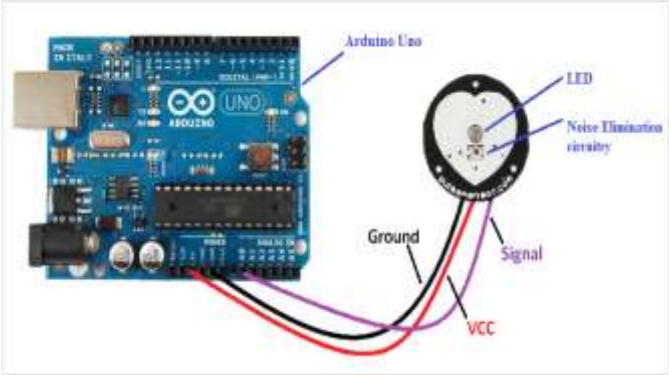

Figure 1 Experimental set up for assessing BPM of the participants.

Brain waves will help one explore how the mind at that point of time functioned The study of [2] is a fundamental scientific study for this analysis. Empiric research was done on 15 special children to determine and examine their cognitive problems. The EEG system was used to monitor the subjects' objective emotions. It was revealed that such sensors are very successful in detecting the latent feelings of selected viewers against triggers. Observed emotions were identified by the artificial intelligence approach. A same EEG-based study was undertaken to test children's brain functions [5]. The author [9] administered a study of eighteen vulnerable children to test their mood reactions toward voice stimuli. They used the ML classifiers to identify the feelings of their target group.

Methodology

Participants

This research was performed to investigate the dynamics of their heartbeat rate, level of meditation, and attention of local speakers against the visual stimuli. Participants were nine males of age 19-60 group. Participants were advised to complete their consent form before joining the experiment activities.

Stimuli

One of the aims of this study is to measure subjects' beats per minute (BPM) to ensure whether they have normal or abnormal BPM. To achieve this task, subjects were asked to speak about themselves for the duration of two minutes. During this activity, their BPM was recorded using a sensor known as a pulse sensor, delivered by www.pulsesensor.com. This sensor works with the open-source gateway like Arduino Uno platform. The working model of this sensor with the circuitry of Arduino Uno to assess the BPM as shown in Figure 1. This sensor captures heartbeats of a person via figure tips. The users have to firmly hold their figure tip on the sensory part of the sensor. Eventually, this sensor captures pulse rate indicating BPM and transfers data to the Arduino Uno platform. Arduino is being used by hundreds of various designs and programs. Arduino Uno functionality is simple that can be used for newcomers, and versatile enough for experienced users. It's operating on various operating systems such as iOS, Windows, and Linux. Educators and administrators use it to create low-cost research tools, to show the concepts of chemistry and physics, or to begin programming and robots [10].

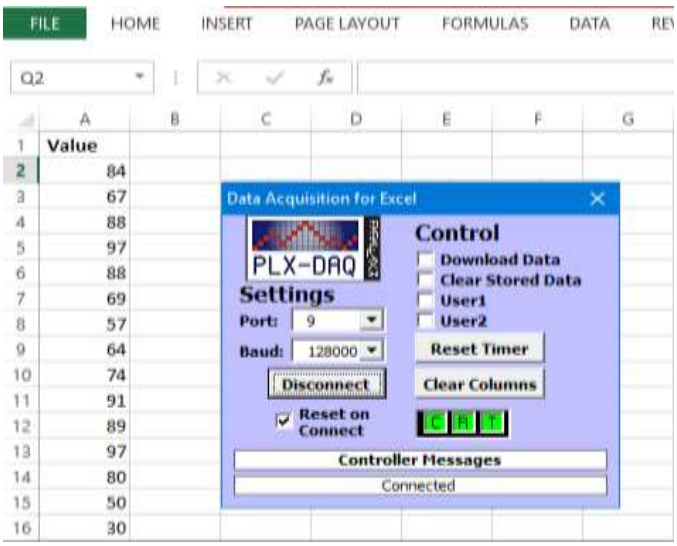

Figure 2 PLX_DAQ add on that transfers data from Arduino Uno to MS Excel.

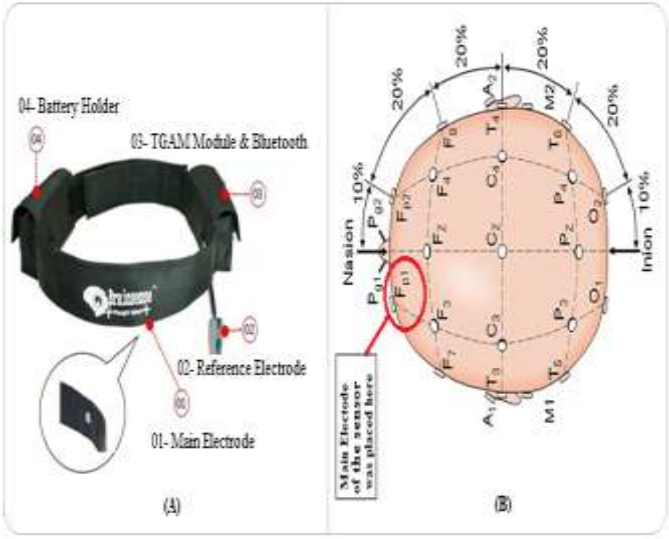

Figure 3 Experimental set up for assessing the attention and meditation states of the participants.

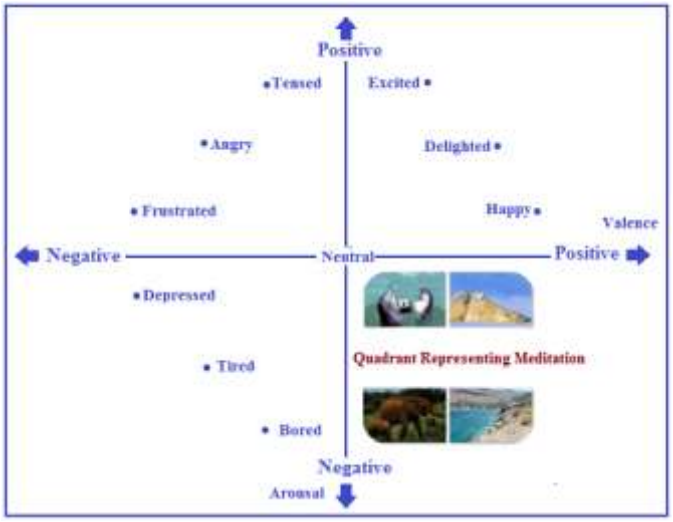

Figure 4 Valence-arousal motion that represents quadrant indicating meditation state.

Figure 2 shows PLX_DAQ add-on for MS Excel that is used to transfer data between Arduino Uno and Excel sheets. Subject's average scores of BPM have listed in Table 1.

The second aim of this study was to measure participants' other two states like attention and meditation. Figure 3 depicts experimental set up for assessing the attention and meditation state of subejcts. In this regard, this study adopted the "valence-arousal" model to capture the attention and meditation level of our targeted audience that was shown in Figure 4 [11]. To provoke the emotion of meditation in subjects, special stimuli were prepared with the photos representing the emotion of meditation. For this purpose, ten relevant photos were picked from the database of IAPS [12]. During experiments, participants had to seat on a chair facing stimuli running on MS PowerPoint by wearing the EEG-based BrainSense sensor on their head (see Figure 3A). This sensor can capture the attention and meditation level of a person against meaningful stimuli. We planned to capture attention ability of participants unknowingly. We just told them to watch stimuli photos and try to provoke emotions of meditation. We wanted to judge whether they focus on their task without any explicit monitoring. Thus, they started to watch the emotion-based images; the sensor was capturing their level of meditation as well as attention.

During experiments, the forehead of subjects was chosen to mount the main electrode of the sensor (see Figure 3A). The reference electrode of the sensor was clipped on subject's left earlobe as this position is suggested by 10-20 international system to capture a level of meditation and attention (see Figure 3B). To store stimulated EEG data of mediation and attention, the sensor was connected to the computer using NeuroView application through Bluetooth. The average scores of meditation and attention were presented in Table 1.

Table 1 Recorded average scores of BPM, Attention and Meditation.

Subject#	BPM	Attention Score (out of 100)	Meditation Score (out of 100)
1	76	35	43
2	95	42	53
3	91	52	58
4	88	33	52
5	131	31	50
6	96	60	70
7	82	39	48
8	89	44	55
9	116	42	28

Results and discussions

This result analysis was based on Table 1. It is well known that the BPM range of a normal person lies between 60 and 100. In accordance with the normal range of BPM, the BPM data of subjects suggests that 78% of subjects have reflected the same range as normal persons have. However, two of them exhibited mean BPM more 115. Hence, we can conclude that the majority of participants were found to be normal in heart beating, but few of them were found to be inconsistent. The initial 20 instances of BPM recordings of every subject were depicted in Table 2.

On the other side, subjects' EEG data of attention show that none of the participants scored 100% attention level.

Table 2 Listing the first 20 data samples of the BPM.

Participants								
1	2	3	4	5	6	7	8	9
68	140	54	90	89	31	99	81	87
69	146	56	91	83	32	101	83	91
73	108	59	91	79	35	100	83	97
76	91	62	90	82	127	104	83	96
70	74	65	90	66	95	40	86	96
65	68	69	89	57	84	40	84	101
64	103	73	88	51	79	43	87	108
65	103	77	88	48	78	98	88	117
65	101	81	88	47	57	98	92	124
60	100	86	88	51	100	85	98	125
60	99	91	87	54	99	84	98	125
62	99	90	86	55	99	87	88	118
62	98	91	85	56	99	72	82	111
62	97	97	86	51	98	72	81	101
68	96	99	86	57	99	73	83	97
73	94	104	87	60	103	75	84	89
76	92	111	88	67	105	78	83	84
75	92	113	88	72	104	80	83	80
75	93	116	88	75	102	82	80	77
82	92	118	88	82	105	81	76	78

On the other end, the EEG data of meditation state reflected that about 78% of subjects recorded meditation value less than 60. Nearly, 33% of them have recorded a mediation value of less than 50. These results suggest that subjects were identified to be deficient in achieving meditation state. The initial 20 instances of the meditation recordings were depicted in Table 4.

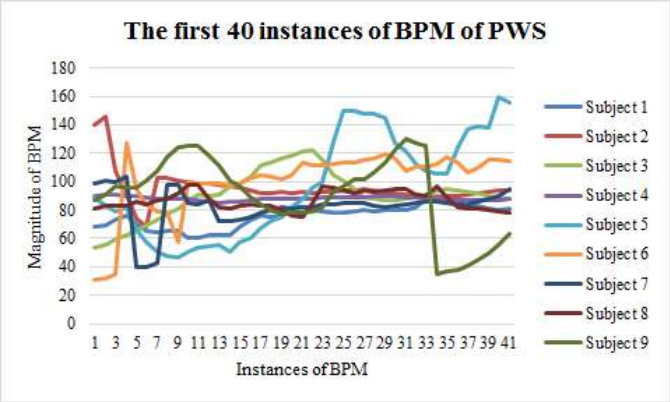

Figure 5 First 40 sample instances of BPM of each subject.

In Figures 5, 6 and 7, the fluctuations that were observed in the readings of BPM, Attention and Meditation have been shown respectively.

Table 3 Listing the first 20 data samples of the attention readings.

Participants								
1	2	3	4	5	6	7	8	9
81	56	67	37	57	44	60	74	41
70	70	54	37	70	40	53	74	43
47	66	54	26	43	35	54	43	47
23	54	50	8	34	37	51	40	40
27	51	60	10	27	43	51	40	34
29	38	61	1	26	70	67	16	14
38	35	69	7	16	75	64	34	4
60	34	64	48	24	74	50	24	26
51	23	63	48	10	80	50	20	26
54	26	56	53	1	64	24	17	27
60	27	56	50	16	61	17	17	38
41	40	56	51	1	60	11	40	41
41	48	51	24	8	56	1	40	30
51	56	53	24	17	70	29	50	26
48	63	41	41	11	77	34	53	29
48	50	27	41	30	78	40	24	23
53	51	26	40	41	77	41	20	30
37	43	27	43	34	67	35	27	43
41	27	35	44	37	53	38	34	51

Table 4 Representing initial 20 instances of the meditation recordings.

Participants								
1	2	3	4	5	6	7	8	9
81	56	67	37	57	44	60	74	41
70	70	54	37	70	40	53	74	43
47	66	54	26	43	35	54	43	47
23	54	50	8	34	37	51	40	40
27	51	60	10	27	43	51	40	34
29	38	61	1	26	70	67	16	14
38	35	69	7	16	75	64	34	4
60	34	64	48	24	74	50	24	26
51	23	63	48	10	80	50	20	26
54	26	56	53	1	64	24	17	27
60	27	56	50	16	61	17	17	38
41	40	56	51	1	60	11	40	41
41	48	51	24	8	56	1	40	30
51	56	53	24	17	70	29	50	26
48	63	41	41	11	77	34	53	29
48	50	27	41	30	78	40	24	23
53	51	26	40	41	77	41	20	30
37	43	27	43	34	67	35	27	43
41	27	35	44	37	53	38	34	51

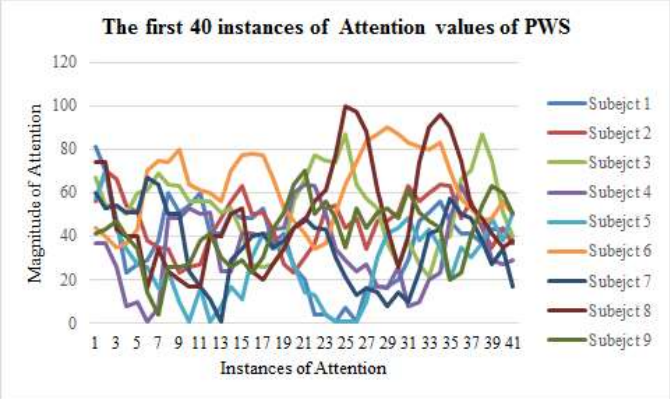

Figure 6 First 40 sample instances of Attention values of all subjects.

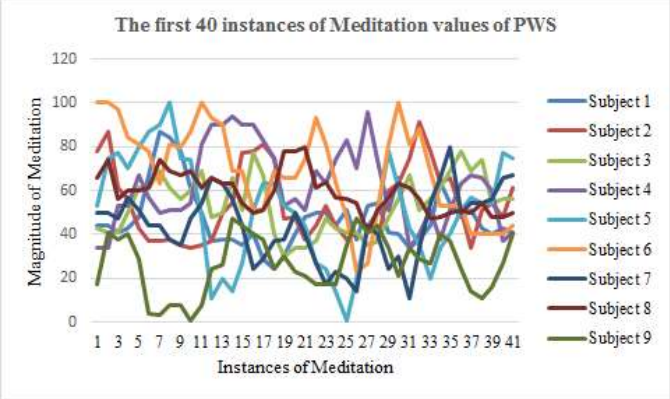

Figure 7 First 40 sample instances of Meditation values of all subjects.

Conclusion and future works

This study sought to present a framework for analyzing some of the key psychophysiological parameters of human. This study can be extended to analyze the same parameters in the domain of children who stutter. This research also can be extended for analyzing emotional changes in adults who stutter. Current BPM was recorded while participants were delivering self-introduction in alone. The current BPM readings can be confirmed by recording their BPM while delivering a public speech. The outcomes of this research can be beneficial to speech therapists to understand psychophysiological factors of their clients.

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