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Neuro Approach to Examine Behavioral Competence: An Application of Visible Mind-Wave Measurement on Work Performance

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ABSTRACT

The purpose of this study was to evaluate the mind-wave of different work performances from the neuro-science approach. NeuroSky's Mindset headset was used as a minimally invasive method to measure the attention, meditation, stress, and fatigue level of the participants' mind-wave during various work performances such as relaxing, playing flute and writing calligraphy. Various mind-wave data were measured as electroencephalogram (EEG), included α wave, β wave, γ wave, and δ wave. Even though there were some limitations of the study, the main finding illustrated that an expert demonstrated higher meditation and lower stress as compared to novice. Visual work performances, like calligraphy writing, tended to significantly need more attention than audio performance ─ like playing a flute. Some recommendations were provided to improve future work performance.

Keywords: NeuroSky's Mindset, mind-wave, electroencephalogram (EEG), work performance, Taiwan

INTRODUCTION

Traditionally, vocational education emphasizes work competence. A performance test is used to measure learners' knowledge and skills to determine their competence. A survey questionnaire can also be used to measure learners' work motivation. However, we perhaps neglect the latent information, such as attention, meditation, stress, and fatigue of a worker. One of the tools to measure those information is electroencephalogram (EGG, in brief). It can be used during various work performances. During the last decade of the 20th century, NeuroSky had developed a non-invasive, dry, bio-sensor to read electrical activities in the brain to determine the states of attention and relaxation. NeuroSky is a low-cost, easy to use electroencephalogram (EEG) developed for leisure. It captures neural activities using three dry electrodes (locations: beneath the ears and the forehead) and decodes them by applying algorithms. NeuroSky provides information on a user's Delta, Theta, Alpha, Beta, and Gamma brainwave levels (Lutsyuk et al., 2006).

The purpose of this study was to measure work performance using mind-wave measurement (EEG) that was non-invasive. The EEG signal is a voltage signal that can be measured on the surface of the scalp ─ arising from large areas of coordinated neural activity. This neural signal varies as a function of performance, mental state, and cognitive activity. The EEG can measurably detect such variation. For example, rhythmic fluctuations in the EEG signal occur within several particular frequency bands, and the relative level of activity within each frequency band has been associated with brain states such as focused attention processing, relaxed meditation, stressed engagement, and frustration which usually are important outcomes of vocational learning (Baker et al., 2010; Berka et al., 2007).

Besides the usual workplace in factory or firm, a school is also an important site to record longitudinal EEG data for several reasons. First, we can analyze the brainwave of the same work performance conducted by experienced or novice individual. Second, we can study brainwave data generated by different work performances from the same learner. Third, we can obtain the inter-correlation or the causality between various work performances such as visual or audio job. Fourth, in the future, we could obtain valid EEG data over a period of time from a relatively big group of learners that would have significant statistical power of “big data”. Then we could analyze the effects of different forms of instruction and practice on students learning and moment-to-moment engagement. Finally, perhaps a longitudinal recording of EEG data on a school-based training program could offer the opportunity to make student-specific model actually useful, by obtaining enough data over time to improve students learning.

To assess the feasibility of collecting useful information about cognitive processing and mental state with a portable EEG monitoring device, the researcher conducted a pilot study in which the participants wore a NeuroSky Mindset while doing different tasks. These EEG data were linked and collected by user ID and timestamp for each second. This study was designed to determine if the Mindset data could distinguish mental states of the participants in various work performances (Rebolledo-Mendez et al., 2009). More specifically, the research questions in this study were as follow:

1. Can EEG detect various work performances for the same subject?
2. Can EEG detect different subjects over the same work performance?
3. What are the EEG causality or inter-correlation between various tasks?

METHOD

Research instrument

The recent availability of a simple, low-cost, portable EEG monitoring device (Figure 1) makes it feasible to take this technology from the lab into schools. The NeuroSky “Mind Set” is an audio headset equipped with a single-channel EEG sensor. It measures the voltage between an electrode that rests on the forehead and electrodes in contact with the ear. Unlike the multi-channel electrode nets worn in labs, the sensor requires no gel or saline for recording, and requires no special expertise to wear. Even with the limitations of recording from only a single sensor and working with untrained users, the Mind Set can distinguish two fairly similar mental states (neutral and attentive) with 86% accuracy (NeuroSky, 2009). In one case, by using NeuroSky Mind-wave device, a patient was found that she could control her mechanical limb with her brain waves (Thakor, 2014). The mind-wave has two dry sensor contacts, one that touches the user’s forehead and another that clips onto the user’s left earlobe (Gearhead, 2012).

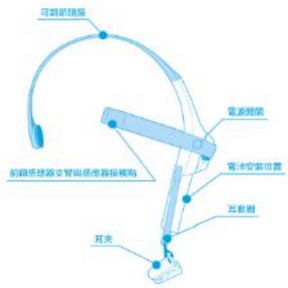

Figure 1: Neuro Sky mind-wave device

Subjects and Research Procedure

There were six subjects participated in this study. All subjects were informed consent to participate in the experiment in the beginning. In this experiment, subjects attended 2-3 tasks for 3-5 minutes. The researcher collected the EEG data of brainwave measurement during the process of conducting the tasks. Synchronously, researcher recorded the experimental process through video as well. There was a software system set up in the computer to record the EEG data via blue-tooth. Subjects had to do specific tasks according to experimental activity, for example, listen to music, write calligraphy, test memory, or play computer game for 3-5 minutes. Primarily, descriptive statistics were used to analyze the EEG data included attention, meditation, stress, and fatigue degree of mental condition derived from the work performance of the participants.

RESULTS AND DISCUSSION

Can EEG detect various performances for the same subject?

According to Table 1, EEG recorded brainwaves for different psychological states. The empirical data showed that most of the subjects differed in their attention, meditation, stress, and fatigue degree after various work performance. In general, playing computer game, taking memory test and writing calligraphy (by master) required higher attention. In contrast, relaxing, playing flute and reading books seem to be high in meditation. However, taking memory test, writing calligraphy (by novice), playing computer showed the participants were highly stressed.

Table 1: Brainwave data of psychological states after performing various tasks

Subject	Work performance	Stat.	Attention	Meditation	Stress	Fatigue
Lu	Playing flute	M	30.74178	77.60094	22.39906	1.553991
		SD	12.61079	18.6344	18.6344	4.49666
	Writing calligraphy	M	45.71591	61.60227	38.39773	4.176136
		SD	14.90001	17.94819	17.94819	5.13939
Lu*	Memory testing after game	M	45.8329	55.04961	44.95039	4.963446
		SD	10.89614	14.28946	14.28946	5.319009
Master	Writing (R) calligraphy	M	38.14375	54.8375	45.1625	6.5625
		SD	15.8891	9.635422	9.635422	7.826489
	Reading (R)	M	36.5848	60.21053	39.78947	6.263158
		SD	17.2418	14.31667	14.31667	6.499393
Li	Relaxing	M	48.56291	85.59603	14.40397	0.397351
		SD	19.47839	12.75209	12.75209	1.007171
	Playing computer gaming	M	42.43333	36.25	63.75	4.116667
		SD	13.04081	14.64496	14.64496	4.124498
An	Relaxing	M	36.76111	52.55	47.45	3.188889
		SD	17.26862	27.14008	27.14008	4.655493
	Writing (2nd) calligraphy	M	44.24444	43.65556	56.34444	6.438889
		SD	15.33813	13.98056	13.98056	8.621244
Hn	Before playing computer game	M	38.99363	56.21656	43.78344	5.764331
		SD	14.7384	16.32432	16.32432	6.904312
	Playing computer game	M	61.92973	67.75135	32.24865	5.52973
		SD	12.65428	10.20352	10.20352	7.551305
	After game memory testing	M	47.67281	57.2212	42.7788	5.182028
		SD	19.94099	14.55901	14.55901	6.390058
En	Relax reading	M	54.07222	53.51111	46.48889	4.266667
		SD	16.77889	13.48928	13.48928	4.244747
	On writing	M	59.83333	46.22222	53.77778	5.066667
		SD	15.21265	14.6846	14.6846	4.9586
	On memory testing	M	59.64177	41.79626	58.20374	6.290323
		SD	15.09197	13.0755	13.0755	6.249266
Hn	Assembling toy robot	M	35.05667	52.33333	47.66667	6.263333
		SD	17.87699	16.57274	16.57274	7.458373
	Assembling robot again	M	42.3	50.52	49.48	7.45
		SD	18.77223	16.62357	16.62357	8.896863
	Memory testing	M	52.28488	54.11337	45.88663	5.409884
	after assembling	SD	23.20461	16.59299	16.59299	6.371541

Can EEG detect different subjects over the same performance task?

Basically, this study showed that varied brainwave data for the same tasks performing by experts and novice. According to Table 2, in writing calligraphy, the novice requires more attention than the experts. Similarly, the novice also indicated high stress in writing calligraphy as compared to the experts. However, the experts showed more stress in playing computer games that the novice. In general, the experts displayed higher meditation state than the novice. The data also showed that the novice needed more attention than the experts in all the tasks.

Table 2: Brainwave data of psychological states after performing various tasks among experts and novice

Subject	Work performance	Stat.	Attention	Meditation	Stress	Fatigue
Lu (mid expert)	Writing calligraphy	M	45.71591	61.60227	38.39773	4.176136
		SD	14.90001	17.94819	17.94819	5.13939
Master (expert)	Writing calligraphy	M	38.57778	55.4	44.6	6.605556
		SD	15.70181	9.561679	9.561679	8.760945
An (novice)	Writing (2nd) calligraphy	M	44.24444	43.65556	56.34444	6.438889
		SD	15.33813	13.98056	13.98056	8.621244
En (novice)	Writing calligraphy	M	59.83333	46.22222	53.77778	5.066667
		SD	15.21265	14.6846	14.6846	4.9586
Lu* (expert)	Memory test after game	M	45.8329	55.04961	44.95039	4.963446
		SD	10.89614	14.28946	14.28946	5.319009
Hn (novice)	Memory test after game	M	47.67281	57.2212	42.7788	5.182028
		SD	19.94099	14.55901	14.55901	6.390058
En (novice)	Memory testing after writing	M	59.64177	41.79626	58.20374	6.290323
		SD	15.09197	13.0755	13.0755	6.249266
Hn* (novice)	Memory test after assembling	M	52.28488	54.11337	45.88663	5.409884
		SD	23.20461	16.59299	16.59299	6.371541
Li (novice)	Playing computer gaming	M	42.43333	36.25	63.75	4.116667
		SD	13.04081	14.64496	14.64496	4.124498
Hn (expert)	Playing computer gaming	M	61.92973	67.75135	32.24865	5.52973
		SD	12.65428	10.20352	10.20352	7.551305

What was the EEG causality or inter-correlation between various tasks?

This study also analyzed the casual correlation of the EEG among these tasks. According to Table 3, it is implied that the longer a subject was working on a task, the higher attention one needs to give. Continuous performance could enhance the attention of the subject. In addition, the meditation may decrease along the consequent tasks. However, the stress and fatigue may increase due to tiredness.

Table 3: The casual correlation among the performance tasks

Subject	Tasks	Stat.	Attention	Meditation	Stress	Fatigue
En	Relax reading	M	54.07222	53.51111	46.48889	4.266667
		SD	16.77889	13.48928	13.48928	4.244747
	On writing	M	59.83333	46.22222	53.77778	5.066667
		SD	15.21265	14.6846	14.6846	4.9586
	On Memory testing	M	59.64177	41.79626	58.20374	6.290323
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	Assembling robot again	M	42.3	50.52	49.48	7.45
		SD	18.77223	16.62357	16.62357	8.896863
	Memory test after assembling	M	52.28488	54.11337	45.88663	5.409884
		SD	23.20461	16.59299	16.59299	6.371541

CONCLUSIONS AND RECOMMENDATIONS

The results of this study have shown that the EEG data from the NeuroSky “Mind Set” recording device can discriminate the mental states included attention, meditation, stress and fatigue between expert-novice subjects and among various tasks performances. Further, this study suggests that EEG can detect transient changes in mental stated in various tasks. The main finding shows that an expert demonstrated higher meditation and lower stress as compared to a novice. Visual work performances, like calligraphy writing, tended to significantly need a user to pay more attention than audio performance ─ like playing a flute. In addition, novice users show higher stress and fatigue during the performance than expert did. In general, the study recommends in the future that a study could be conducted to detect mental states relevant to the learning domains, such as comprehension, engagement, and learning. In a longitudinal study, across different types of learners, EEG method could be used to test the mental states in different contexts of learning ─ elucidate the interplay among emotion, cognition, and learning, and possibly to identify the appropriate teaching methods according to varied mental states. In conclusion, this pilot study suggests that EEG device could be useful in the school’s context to capture the critical data of the learners’ mental states in doing various tasks.

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