Using Brain and Bio-Signals to Determine the Intelligence of Individuals

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***Abstract*—This study shows how intelligence of an individual can be determined in different intelligence domains using brain and bio-signals. Results of pupil dilation, eye-blink and EEG (Electroencephalogram) signals were analyzed. It was found that high intelligent individuals (HI) could easily modulate their resource allocation and information processing strategy than low intelligent individuals (LI) depending on task demand.**

Keywords-multiple intelligence; pupil dilation; eye blink; EEG; coherence analysis.

I. INTRODUCTION

Intelligence is one of the characteristics that define human beings. However, in practice, the level of intelligence varies from individual to individual. At one level it varies in degree and at another it varies in kind. In contrast to the traditional view that intelligence of an individual can be measured with a single score, researchers have argued that individuals are intelligent in their own different ways. For instance, some are good in logic while some are good in language. This idea is strongly supported by the theory of Multiple Intelligence (MI) proposed by Howard Gardner [1]. Gardner chose eight following domains of intelligence - musical-rhythmic, visual-spatial, verbal-linguistic, logical-mathematical, bodily kinesthetic, interpersonal, intrapersonal and naturalistic.

While the nature of intelligence is debated, the method to measure them individually or together has also turned out to be a big area of research in educational psychology. Several methods such as questionnaires and personal interviews have been proposed. Questionnaires are cheap but do not give an estimate of subjective potential of an individual. Personal interviews do provide a subjective insight into the potential of an individual but they are time consuming and expensive. Therefore, there is a great need to explore alternative methods to assess the potential of an individual in different intelligences that are cheap, readily available and subjective. We conducted our experimental studies to asses the intelligence of an individual based on their brain and bio-signals such as pupil dilation, eye blink, Galvanic Skin Response (GSR), heart-beat and body temperature. In this paper, we focus on brain and eye-movement analysis.

Previous studies have shown that bio-signals, particularly, pupil dilation and eye blinks provide complimentary indices of information processing [2]. In general, pupil dilates when the processing demand is higher. Pupil dilation also indicates sustained information processing [3][4]. Similarly, eye blinks also indicate cognitive processing [5]. Some independent studies on eye blink have shown that eye-blink bursts follow high cognitive load or information processing [6][7]. This suggests that eye blinks reflect the release of resources used in stimulus related cognition [8]. While bio-signals reflect the cognitive processing and resource allocation, brain signal analysis using EEG such as power analysis and coherence also indicate mental activity [9][10].

The present paper is structured as follows: In Section II we focus on the experiment design and in Section III we discuss the results. In Section IV we present the conclusions.

II. PRESENT STUDY

We report our experiment to determine the intelligence of an individual in fundamentally two different domains namely language and visuo-spatial. In the experiment, 40 high school students (divided into high and low intelligent individuals based on a pre-test) solved 20 questions that were divided into tough and easy (10 from each domain). While participants solved the questions, their pupil dilation was measured using tobii eye tracker and eye blink was measured using a web-camera. Their brain signals were acquired using bio-semi EEG device with 32 channels. To better understand the processing mechanism of participants, the trials were divided into three conditions: pre-stimulus, during-stimulus and post-stimulus. Change in pupil dilation, eye movement and brain signals during problem solving were contrasted with rest state.

III. RESULTS

Results of pupil dilation (Table 1) show that high intelligent individuals have greater change in pupil dilation for tougher questions and in tasks that require creativity and imagination (i.e., visuo-spatial tasks), and lesser change in pupil dilation for easier questions and in tasks that require algorithmic approach (i.e., language). Low intelligent individuals have significant increase in all conditions, which indicates higher processing load. High intelligent individuals showed higher eye-blink rate for tough and creative tasks than low intelligence individuals.

Similarly, results of EEG coherence (Figure 1) showed higher coherence between pairs of electrodes in frontal lobe in theta and alpha band (but not in other bands) for higher intelligent individuals for language tasks. For visuo- spatial tasks, high intelligent individuals showed wide spread coherence indicating a networking of various brain regions.

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TABLE 1. CHANGE IN PUPIL SIZE AND EYE BLINK RATE IN LANGUAGE AND VISUO-SPATIAL DOMAIN FOR HIGH AND LOW INTELLIGENT INDIVIDUALS

		Tough Task				Easy Task			
		High-Intelligent (HI)		Low-Intelligent (LI)		High-Intelligent (HI)		Low-Intelligent (LI)	
		Pupil variation %	Eye-blink/sec	Pupil variation %	Eye-blink/sec	Pupil variation %	Eye-blink/sec	Pupil variation %	Eye-blink/sec
Language	Pre-test	23.2*	0.78*	17.3*	0.62*	14.93	0.41	5.41	0.43
	During-test	36.1	0.34*	28.49	0.52*	2.18*	0.57	15.03*	0.32
	Post-test	11.2	0.87*	-1.72	0.32*	5.89	0.65	9.82	0.50
Visuo-spatial	Pre-test	17.12*	0.72*	4.65*	0.64*	19.7*	0.52	-3.78*	0.45
	During-test	39.71**	0.43	22.6**	0.42	7.53*	0.22	10.24*	0.52
	Post-test	9.82	0.89*	8.03	0.41*	17.71	0.75	-1.05	0.35

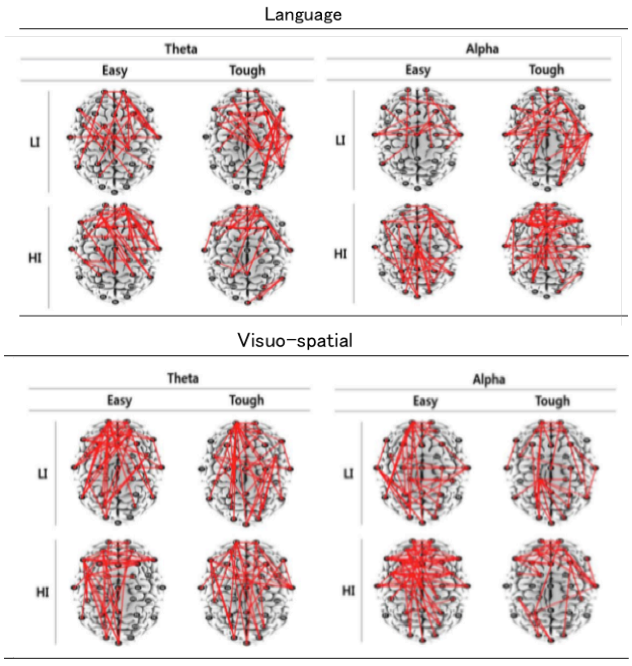

Figure 1. Significant electrode pairs of HIs and LIs during easy and tough tasks in theta and alpha bands in language and visuo-spatial domains (confidence level set at .05)

IV. CONCLUSION

Overall, our results present following important findings: First, high intelligent individuals modulate their brain resource allocation patterns according to demand of the task. In contrast, low intelligent individuals allocate more resources for all kinds of tasks. Second, high intelligent individuals allocate restricted brain areas for tasks that require fewer resources but different brain regions for tasks that require additional resources. Overall, these findings showed that individuals with different potentials have different ways of processing information. Moreover, bio and brain signals can be reliably used to assess the intelligence. In future we will explore other domains of intelligence.

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