

Difference of 3-back task performance due to three levels of arousal

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Abstract: The purpose of this study was to investigate how three levels of arousal affect performance of a 3-back task. Ten university male (25.7 ± 1.5 years) and ten female (age 24.5 ± 1.8 years) students participated in this experiment. Using pictures selected from a group test, three levels of arousal (arousal, neutral, and relaxed emotions) were induced. Each subject was run through the procedure three times, once for each arousal level. The procedure consisted of six phases for each arousal condition; Rest 1 (2 min), Picture 1 (2 min), 3-back Task 1 (2 min), Picture 2 (2 min), 3-back Task 2 (2 min), and Rest 2 (2 min). Skin conductance level (SCL) of electrothermal activity was also measured during all phases of the experiment. The accuracy rate of 3-back task performance was the highest at a neutral emotional state. Based on the results, it could be inferred that arousal emotion, induced by stimuli unrelated to cognitive tasks, decreases the ability to perform cognitive tasks.

Keywords: Arousal level, 3-back task, cognition ability.

I. INTRODUCTION

Recent studies showed that one axis of two-dimensional space (pleasantness-unpleasantness) might influence on cognitive processing abilities such as memory. People memorized pictures which induced negative (unpleasantness) emotion better than pictures which induced neutral emotions [1].

Some studies reported that emotional arousal influences on information processing [2, 3]. The emotional arousal controls consolidation of memory [4]. Using emotional Stroop task, subjects at high level of anxiety took longer reaction time to report the color names of threat words than those of non-threat words [5]. The results indicate that emotional arousal level might affect human being's cognitive ability.

This study examined how the arousal axis of human emotion affects cognitive performance ability by using three levels of arousal induced by emotional pictures and appropriate cognitive task measuring immediate memory. After inducing each level of arousal, it was observed how these arousal states influenced the accuracy of a 3-back task. To check whether the proper arousal level was achieved by using emotion inducing pictures, skin conductance level (SCL) of electrothermal activity was measured and subjective evaluation was performed after experiment.

II. METHODS

Ten healthy male (25.7 ± 1.5 years old) and ten healthy female (24.5 ± 1.8 years old) university students participated in the study.

Biopac MP30 and acqknowledge 3.5 (Biopac System, Inc. USA) were used to measure the SCL from the index and middle fingers on the left hand (sampling rate: 500 samples/sec).

The experiment consisted of three runs of a 3-back cognition test. The procedure consisted of six phases for each arousal condition; Rest 1 (2 min), Picture 1 (presenting emotion arousing photos for 2 min), 3-back Task 1 (2 min), Picture 2 (presenting emotion arousing photos for 2 min), 3-back Task 2 (2 min), and Rest 2 (2 min).

During 3-back Task 1 & 2 phases, a total of 80 alphabetical characters were presented and total correct answer was 20. The subject was asked to press the answer button if the currently presented character was same to the third previous presented character. The pictures and 3-back tasks were presented using SuperLab 1.07 (Cedrus Co. San Pedro, USA).

SCL of each subject was normalized by the Rest 1 value after calculating the average value of each phase. To investigate if there was any statistical difference under the three arousal levels and between each phase of SCL, two-way repeated measures ANOVA was employed with arousal level and phase as independent variables. The accuracy rate on the 3-back test was calculated. Significance in the differences in accuracy rate based on arousal levels were determined using one-way repeated measures ANOVA.

III. RESULTS

As shown in Figure 1, the mean SCL at each phase was the greatest during presentation of the arousal

pictures, then neutral and relaxed pictures in order. Two-way repeated measures ANOVA showed a significant difference in the arousal level ($F=4.393$, $df=2$, $p=0.019$) and phase ($F=9.493$, $df=4$, $p<0.001$).

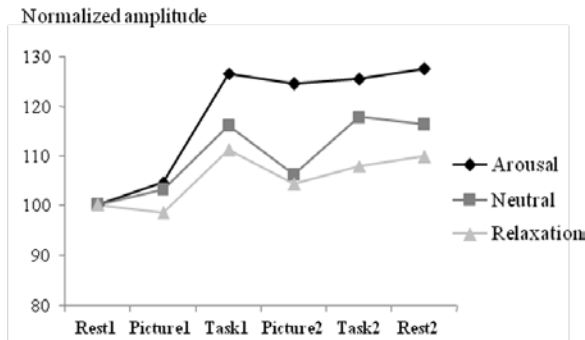


Fig.1. The normalized amplitude of SCL in each phase by 3 types of emotion induced pictures

As shown in Figure 2, the accuracy rate of the 3-back task was the highest when presented with neutral pictures (78.0 ± 16.4 [%]), then relaxed pictures (74.0 ± 15.7 [%]), and then arousal pictures (70.3 ± 14.4 [%]), in order ($F=4.938$, $df=2$, $p=0.012$).

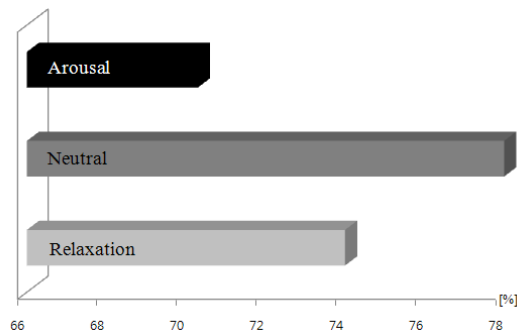


Fig.2. The accuracy rate by 3 types of emotion

IV. DISCUSSION

This study investigated the effect of arousal level on the performance of a 3-back task.

Physiological stimulation especially had a negative effect on information processing of succeeding input [6], and it was reported that the increase in physiological stimulus had a negative effect on cognitive processing [7]. From these studies, it could be inferred that the increase in the physiologically arousal state, which is irrespective of cognitive processing, had a negative effect on information processing of succeeding input. From this, it would be expected that the ability of performing a 3-back task would decrease, as shown in this study.

It was well known that cognitive processing activated the sympathetic nervous system [8]. Inducing a relaxed state of this study can activate the parasympathetic nervous system, and by disturbing the concentration for a given task, it can be expected that the ability to perform a given task decreases.

Preceding studies about the valence axis showed that people could remember much more items when emotion is accompanied, whether or not the memory was related with tasks [1, 9]. This study on the arousal (arousal/relaxation) axis showed that the memory ability without emotion was higher. Therefore, it is necessary to clarify how the human emotional state affects cognitive processing ability by considering both axes of human emotion at the same time.

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