Changes in Cognitive Performance due to Three Types of Emotional Tension

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Abstract

The purpose of this study was to investigate how three types of emotional tension levels affect performance of a cognitive task. Ten university male (age 25.7 ±1.5) and ten female (age 24.5 ±1.8) students participated in this experiment. We used a 3-back task as a cognitive task. Using pictures selected from a group test, three types of tension levels, i.e. tensed, neutral, and relaxed emotions, were induced. The experimental design consisted of six phases; Rest 1 (2 min), Picture 1 (presenting emotion tensioning photos for 2 min), 3-back Task 1 (2 min), Picture 2 (presenting emotion tensioning photos for 2 min), 3-back Task 2 (2 min), and Rest 2 (2 min). Galvanic skin response (GSR) 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, followed by relaxed and then tensed emotional state. Through this study it could be inferred that tension, induced by stimuli unrelated to cognitive tasks, decreases the performance of cognitive tasks.

Keywords: Cognitive performance; Emotion; Tension level; Accuracy

1 Introduction

Many researchers have examined diverse aspects of human behavior, including behavioral changes, subjective assessment, and physiological responses, to study emotion [1-4]. Psychologists who used the discrete state model to understand the inner states of human beings argue that emotion could be classified into several categories [2,4]. According to the dimensional model, the inner states can be placed in a two-dimensional space [5-6]. In other words, each emotion is positioned in a circular space with the two dimensions of valence (pleasantness-unpleasantness) and tension (tension-relaxation). The two-dimensional structure is considered a fairly stable and general structure for human emotion.

Recent studies showed that one axis of two-dimensional space, pleasantness/unpleasantness emotion might have an influence on cognitive processing abilities, especially memory. Kensinger, Garoff-Eaton, and Schacter [7] reported that people memorized pictures which induced negative (unpleasantness) emotions better than pictures which induced neutral emotions. The memory difference in event-related details and personal details was investigated for those who watched the same baseball game (winning team: positive emotion, losing team: negative emotion, those who not a fan: neutral emotion) [8]. The same memory test was performed immediate after and six months after the game, and the amount of memory, memory consistency, confidence and vividness was measured. Results showed that those who had negative emotions while watching the game scored the highest in the amount of memory, memory consistency, confidence and vividness, with positive and neutral emotions ranked in order.

Previously, it was widely held that the memory which was influenced by emotion was distorted or more easily forgotten [9], but recent studies reported that the memories related to emotion were kept more vividly and in greater detail [7-8,10]. Many studies concerning changes in cognitive ability due to emotion have been carried out, but have been confined to the valence aspect (positive/negative) [7-10].

Therefore, this study investigated how the tension axis of human emotion affects cognitive performance ability. After inducing three emotions, tension, neutral and relaxation via pictures, it was observed how these emotions influenced the accuracy of a 3-back task. To measure changes in cognitive performance ability, a 3-back task which can exclude the learning effect was used in this study. To check whether the proper tension level was achieved by using emotion inducing pictures, galvanic skin response (GSR) was measured and subjective evaluation was performed after experiment.

2 Methods

To induce the proper emotion for experimental purpose, pictures were selected using a group test. The group test was performed with 73 university students (age 26.0 ±1.6). 300 pictures from the international affective picture system (IAPS) were used during the group test [11]. Participants were advised to mark questionnaires on a 5 point scale (tensed/pleasant 5, neutral 3, and relaxed/unpleasant 1) based on the tensed-relaxed and pleasant-unpleasant degrees after looking at each picture. After the group test, the average of the tensed-relaxed and pleasant-unpleasant degrees of 300 pictures was calculated. 24 pictures for the tensed emotion were selected in the order of the highest average of tensed-relaxed degree while closest to point 3 in pleasant-unpleasant dimension. 24 pictures for the neutral emotion were selected in the order of the closest to point 3 in both dimensions, and 24 pictures for the relaxed emotion in the order of the lowest average of tensed-relaxed degree while closest to point 3 in pleasant-unpleasant dimension. The average of selected pictures was 3.9±0.7 for the tensed, 2.9±0.3 for the neutral, and 1.6±0.9 for the relaxed. Results of one-way repeated measures ANOVA using SPSS ver. 12.0 (SPSS Inc. Chicago, Illinois) showed that there was a significant different among three types of emotion induced pictures as shown in Figure 1 (a) ($F=40.419$, $df=2$, $p<0.001$). In contrast, the differences in pleasant level were not significant among three types of pictures ($F=2.076$, $df=2$, $p=.131$).

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. None of the participants reported having a history of psychiatric or neurological disorders. The overall experimental procedure was explained to all subjects who released consent for the procedure. All examinations were performed under the regulations of our Institutional Review Committee.

Biopac MP30 and acqknowledge 3.5 (Biopac System, Inc. USA) were used to measure the average amplitude of galvanic skin response (GSR) from the index and middle fingers on the left hand. The sampling rate of the physiological data was 500 samples/sec.

The experiment consisted of three runs of a 3-back cognition test. Each run consisted of six phases: Rest 1 (2 min), Picture 1 (presenting emotion tensioning photos for 2 min), 3-back Task 1 (2 min), Picture 2 (presenting emotion tensioning photos for 2 min), 3-back Task 2 (2 min), and Rest 2 (2 min). Rest 1 was a 2-min stabilization period. During Picture 1 phase, 12 emotion inducing pictures selected from group test were presented randomly at a 10 seconds interval. During Picture 1 & 2 phases total 24 emotion induced pictures were presented. During the 3-back Task 1 phase, one of 40 alphabetical characters was presented at a 3 seconds interval. The subject was asked to press the answer button if the currently presented character was same to the third previous presented character. Among them the number of correct answer was ten. During 3-back Task 1 & 2 phases, a total of 80 alphabetical characters were presented and total correct answer was 20. Six sets of 3-back tasks were made. The six 3-back task types were counterbalanced across each run. The pictures and 3-back tasks were presented using SuperLab 1.07 (Cedrus Co. San Pedro, USA). Rest 2 was a 2-min rest period. Each subject was

run through the procedure three times, once for each tension level. The experimental order was randomized. Subjects rested for 1 hour between runs. After each run, the subjects estimated their tension level induced by the pictures using a 5 point scale (tensed 5, neutral 3, and relaxed 1). GSR was measured in all phases.

The amplitude of GSR 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 tension levels and between each phase for amplitude of GSR, two-way repeated measures ANOVA was employed with tension level (the tensed, neutral, and relaxed) and phase as independent variables. The accuracy rate on the 3-back test was calculated. Significance in the difference in accuracy rate based on tension levels was determined using one-way repeated measures ANOVA.

3 Result

Figure 1 (b) shows the self estimated results of the induced emotion. The tension level was 3.9±0.6 for the tensed pictures, 2.7±0.7 for the neutral pictures, and 1.5±0.5 for the relaxed pictures. This result was similar to the tension scores (Figure 1 (a)) from the group test. One-way repeated measures ANOVA showed a statistical difference among tension levels of 3 types of emotion induced pictures ($F=41.511$, $df=2$, $p<0.001$).

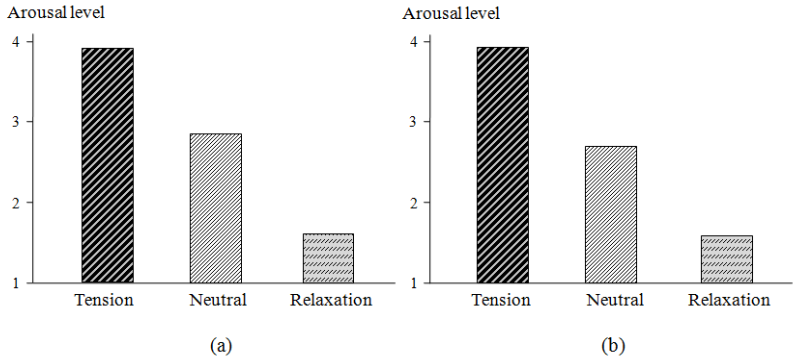

Figure 1. (a) Magnitude of tension level for tensed, neutral and relaxed pictures from group test (b) Results of subjective evaluation for 3 types of emotion induced pictures after each experiment.

Figure 2 showed the mean amplitude of GSR at each phase at presenting 3 types of emotion inducing pictures. As shown in Figure 2, the mean amplitude of GSR at each phase was the greatest during presentation of the tensed pictures, then neutral and relaxed pictures in order. Two-way repeated measures ANOVA showed a significant difference in the tension level ($F=4.393$, $df=2$, $p=0.019$) and phase ($F=9.493$, $df=4$, $p<0.001$). Since there was an interaction effect ($F=2.016$, $df=8$, $p=0.048$) between the tension level and phase, there was a difference in changes of GSR based on the types of tension levels.

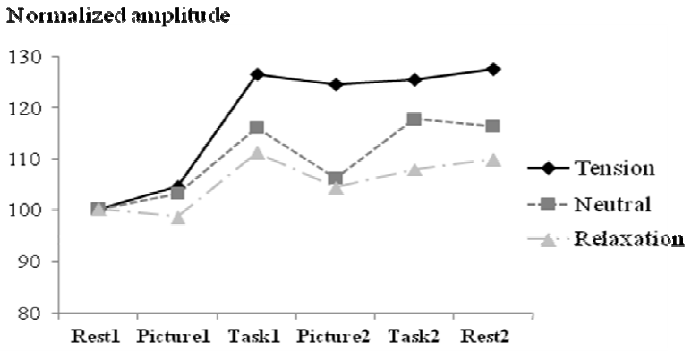

Figure 2. The normalized amplitude of GSR in each phase by 3 types of emotion induced pictures.

As shown in Figure 3, 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 tensed pictures (70.3 ± 14.4 [%]), in order (F=4.938, df=2, p=0.012).

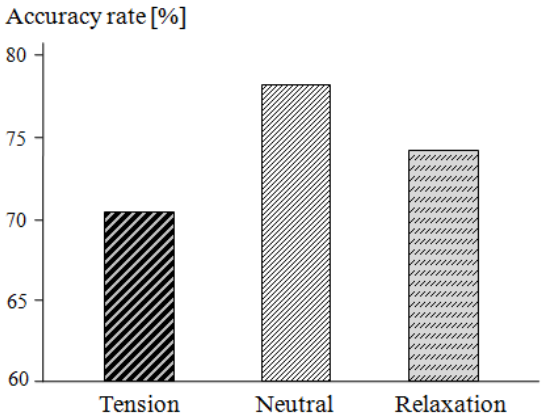

Figure 3. Accuracy rate of the 3-back task by 3 types of emotion induced pictures.

4 Discussion

This study investigated the effect of tension level on the performance of a 3-back task. It was well known that GSR reflected tension levels sensitively [12-13]. As shown in self estimated results in Figure 1 and in the GSR in Figure 2, the 3 types of pictures used in this study induced 3 types of tension level effectively.

Results showed that the accuracy rate of the 3-back task was the highest at a neutral emotional state, then a relaxed state and a tensed state, in order. Therefore, it could be concluded that the performance of a 3-back task increases when in a neutral emotional state compared with tensed and relaxed.

It has been reported that the change in feeling due to external stimuli had an effect on cognitive processing, judgment, and evaluation through indiscreet ignition stage unconsciously without conscious intervention process [14-15]. Physiological stimulation especially had a negative effect on information processing of succeeding input [16-17], and it was reported that the increase in

physiological stimulus had a negative effect on cognitive processing [18]. From these studies, it could be inferred that the increase in the physiologically stimulated state (tensed 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 [19-20]. Attention and concentration on a given task was accompanied by the activation of the sympathetic nervous system. 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.

The tension (tension/relaxation) axis of human emotion is closely related to physiological awakening, unlike the valence (pleasantness/unpleasantness) axis. From this study, it can be inferred that the increase or decrease in the physiologically stimulated state, which is irrespective of cognitive processing, decreases the ability of performing tasks by disturbing proper concentration for given tasks.

Preceding studies about the valence (pleasantness/unpleasantness) axis showed that the memory ability with emotion was higher, whether or not the memory was related with tasks [7-8,10]. This study on the tension (tension /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.

Acknowledgments

This work was supported by Mid-career Researcher Program through NRF grant funded by the MEST (No. 2009-0084784)

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