Cognitive impact differs from relationship of scene and facial expression

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***Abstract*—Attentional bias for threat, which causes time delay in reaction to simple tasks in psychological trials, has been found in recent studies. In this study, scenes with different qualities for the background and eigenfaces with different expressions for the foreground were chosen to examine the various reaction times of participants to shed light on the neural chronometry of cognitive bias. According to the analysis of Minnesota Multiphasic Personality Inventory (MMPI), images from the International Affective Picture System (IAPS) were classified as background containing positive, neutral, or negative information; 5 eigenfaces with positive or negative expressions were used as foreground (target). A discrimination task and a competition task were designed to test the subjects' attentional bias under contrast/correlative information. Keyboard-Press Times (KPTs) were recorded as the participants performed the tasks. Results showed that negative information could result in reaction time delay in facial expression cognition in general; and this affection not only appeared to the cognitive procession of expression, but also affected by the information from environment. The data suggest that cognitive procession to facial expression was affected not only by the main information of itself but the context within which it is perceived.**

Keywords: cognitive speed; reaction time; attentional bias; emotional image

I. INTRODUCTION

Recent studies both on psychology and neuroscience reveal that there is a substantial interaction between the behavioral system and image cognition. Psychological methods established new ways to access reaction time from designated tasks, first, discovering attentional biases in the emotional Stroop task using paradigm [1] and, then, exploring its features in regard to individuals with special trait anxiety using probe detection tasks [2]. All of the tasks demonstrated that negative information interferes with an individual's cognitive speed [3, 4]. Furthermore, attentional biases for emotional faces were found to be particularly useful because high trait anxiety may indicate avoidance of or vigilance for threatening faces [5, 6]. These studies lead to the open question that how correlative/contrast information from environment and human-beings might affect cognitive processing speed and the behavioral system.

In this study, psychology experiments containing scenes and eigenfaces were used to simulate environment with information of different properties and detected psychological statuses towards emotional factors. Psychologists constructed inventories to test personality and could provide a wide range of view to decide what property scenes should have. A new database, with guideline of the mostly used Minnesota Multiphasic Personality Inventory (MMPI) [7], was built to generate the stimuli containing negative/neutral/positive background information. Eigenfaces with emotional expressions, which maintained facial main features by feature-based techniques [8, 9], were used as targets that eliminated details about gender, race, etc., to avoid ethnic or cultural factors. Participants performed simple discrimination tasks (i.e., to discriminate the expression of the face as positive or negative) after watching the emotional background pictures which were paired under constructions. Some participants' data of Event Related Potential (ERP) was recorded for further explorative analysis.

In the design of the experiment, the generation of synthetic images with images in the database using multi-element synthesis was based on principles of antagonistic relationship and interdependence in psychological analysis [10]. A target probe followed the displays consisting of pictures selected from the International Affective Picture System (IAPS) [11], which were under the direction of a basic conclusion of the MMPI. The foregrounds (targets) were eigenfaces specifically chosen and generated from the facial libraries, containing expressions of negative and positive emotions. Specifically, negative expression was divided into anger, disgust, fear and sadness [12]. Subjects were asked to complete simple tasks as quickly as possible to provide reaction time performance. Finally, all data were analyzed to provide a predictable behavioral pattern of picture cognition. Figure 1 is the fundamental framework of the research.

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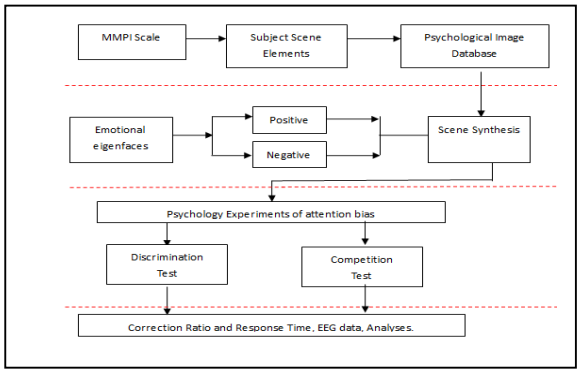

Figure 1. Fundamental framework of the research

II. METHODS

A. Participants

17 participants (7 females and 10 male, age 21-24, Mean = 23.12, SD = 1.166) from Tsinghua University performed the experiment. All had normal or corrected to normal vision and reported no history of neurological problems. 3 of them (Mage = 22.33, SD = 1.155) accepted to record EEG data. Informed consent was obtained from each participant; Participants were paid 100 RMB for their participation.

B. Materials

Based on Osgood's seminal work assumed that emotion could be defined by a coincidence of values on a number of different strategic dimensions [11, 13], we hypothesized about combining all of the three dimensions: valence (ranging from pleasant to unpleasant), arousal (ranging from calm to excited), and dominance [14], into one dimension, that is, positive (pleasant) or negative (unpleasant). Moreover, all of the images in the database were selected on the basis of the theory of the MMPI [7] to assign a keyword. The database contains 90 themed background scenes from the IAPS (For protocol and research reasons, original pictures from IAPS should not publish on papers). Picture's topics including wide range from physical state to psychological state, could cover the most topics from MMPI. Also, these pictures assign a property according to IAPS's guidebook [11].

The main scenes are divided as the following table I:

TABLE I. KEYWORD OF MAIN SCENES

Scene Type	Psychological/Physical Basics	Keyword in MMPI
physical state	Vegetative nerve	Drinks a lot
Psychological state	Emotion, pressure	Afraid of darkness
Social relation	Confidence	Easy-going
World view	Religion, philosophy	Belief in God
Self and social acknowledgement	Self-access, justice	Life is crucial
Synthetic factors	--	Afraid often
Sex	Prejudice, appearance	Gender awareness
Activity, interest	Adventure, work	Careful gait

C. Task design

Preliminary experiments including tasks, such as discrimination and competition, were designed to test the hypothesis. These tasks were used to extract quantitative parameters on reaction times as the subject watched synthetic images in the trials. The reaction time was automatically captured and quantitatively analyzed by the computer.

The preliminary experiments include:

(1) Discrimination task: An emotional face appeared after a background image was shown (ranging 1000ms – 1200ms [20]). The participant must provide his/her judgment on the face's emotion and react rapidly when he/she recognized the expression. The experimental goal is to test the subjective discrimination time of the correlative/contrast emotional information of the background (scenes) and foreground (eigenfaces).

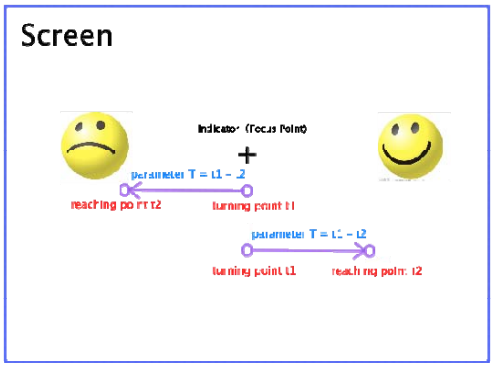

Figure 2. Example of procedure in task 2. (For protocol and research reasons, background was not one of the primary pictures of the IAPS, and the eigenfaces were replaced by symbols)

(2)Competition task: the procedure is as same as the first one except that the background contained two images, one with positive/negative quality, and another with neutral quality. The experimental goal is to test the subjective discrimination time of the correlative/contrast emotional information of the background (scenes). Here, the subjects' points of focus were assumed to be the center of picture because of instructions given before the trials including maintaining their gaze on the center of the screen. (Figure 2).

D. General procedure

Each trial in the discrimination procedure task began with flat screen displayed for a period of time (2000 ms) followed by the pictures from the database for 1000 ms, in which the target eigenface display was added after a random time (ranging from 500 ms to 1000 ms). The eigenface was at the center of the screen, with randomly emotional expressions. Participants were directed to determine the expression of the target and to respond by hitting the key as quickly as possible (if the expression is joy, press 'F'; or else, press 'J').

The procedure of each trial in the competition task was almost the same as the discrimination procedure. This task was performed 2 days after the discrimination task.

In both tasks, the participants were first trained by a set of 20 trials with examples from an affective category. During this procedure, the participants were trained to maintain their gaze on the center of the screen and to avoid any explorative eye movements. To this end, the experimenter, who visually inspected the data generated from the computer, provided feedback. Subsequently, the participants completed the following 800 trials. The participants were able to choose a time to take a break to avoid fatigue. The whole procedure lasted about an hour.

E. Data recording and analysis

For each individual observer, the mean reaction time was calculated in both tasks under different conditions. Trials with reaction times that exceeded two standard deviations above or below each participant's mean reaction time (calculated separately for each experimental condition) were rejected. Trials with incorrect responses and responses faster than 250ms and responses slower than 900ms were also discarded. About 5% of all trials were excluded from the analyses.

In both tasks, a 2 * 2 ANOVA was performed with contrast emotional condition as a within-subject for each participant. Followed one-sample t-tests against zero were used to determine the significance of within-group biases.

III. RESULTS

A. Reaction time data

Mean RTs, and standard deviations by scenes and eigenfaces are presented in Table II.

TABLE II. MEAN REACTION TIMES AND STANDARD DEVIATIONS IN MS BY EACH CONDITION IN TASK 1

Task	Scene property	Eigen face Property	Mean RT (MS)	Std. Error
1	positive	positive	625.176	8.948
		nagetive	661.779	13.049
	nagetive	positive	639.000	9.837
		nagetive	666.794	12.263
2	positive-neutral	positive	683.117	23.654
		nagetive	687.853	25.669
	nagetive-neutral	positive	684.058	23.491
		nagetive	677.897	23.425

B. Reaction time analysis

In task 1, structural eigenfaces with positive emotional expressions paired with scenes of positive content that were selected for the discrimination task resulted in significantly shorter response times than did all of the other combinations, whereas eigenfaces with negative emotional expressions paired with scenes of negative content that were selected for the discrimination task resulted in significantly longer response times than did all of the other combinations. A repeated-measures analysis of variance, with discrimination reaction time to affective eigenfaces as the dependent variable and affective scene property as the repeated measure, was statistically significant ($F(1,16) = 12.938$, $p < 0.002$). Follow-up t tests revealed that positive eigenfaces paired with positive scenes produced significantly shorter response times than positive faces paired with negative scenes[$t(16) = 4.747$, $P < 0.001$]. However, negative eigenfaces paired with positive scenes show no difference in reaction time with negative eigenfaces paired with negative scenes ($t(16) = 1.275$, $p < 0.220$). The environmental information only influenced the cognition procession of positive expression. The repeated-measures analysis of variance, with discrimination reaction time to affective eigenfaces as the dependent variable and affective eigenface property as the repeated measure, was also statistically significant ($F(1, 16) = 13.796$, $p < 0.002$). Follow-up t tests revealed that positive eigenfaces produced significantly shorter time than negative eigenfaces both paired with positive scenes ($t(16) = 3.972$, $p < 0.001$) and paired with negative scenes($t(16) = 3.197$, $p < 0.006$). On average, the correlation between eigenfaces and emotional scenes were not significant ($F(3, 16) = 0.651$, $p < 0.634$). Our finding that cognitive procession of facial expressions in emotional scenes with negative information resulted in slow reaction times is consistent with other research showing that unpleasant stimuli capture attention [15], and contribute to the efficiency problem in discrimination [16].

In task 2, reaction time did no differ significantly from different conditions. A repeated-measures analysis of variance, with discrimination reaction time to affective face as the dependent variable and affective scene property as the repeated measure, was statistically significant ($F(1,16) = 5.707$, $p < 0.030$). Follow-up t tests revealed that eigenfaces with negative expression paired with negative scenes produced significantly shorter response times that with negative scenes [$t(16) = 2.906$, $P < 0.010$]. There was no difference in mean reaction time for eigenface as the repeated measure ($F(1, 16) = 2.000$, $p < 0.176$). The result show that the cognitive speed was still affected by the eigenfaces, however, the whole cognitive speed slowed down when scenes (environment) contained contrast information.

IV. DISCUSSION

One possible interpretation of the data from task 1 is that under normal conditions, positive information might cause attentional bias, enhance the activity of brain function, and accelerate the cognitive speed [17]. Another possibility is that the dealing of negative information made participants trap deeper and cause reaction time delay [18]. However, when environmental information differed from the information passed by faces (human-beings), the main impact was still from the facial part, especially when dealing with negative information, the environmental factor could be ignored. Task 2 confirmed this by showing participants the contrast information in background (environment), and results show that cognitive

speed slowed down in general but show no difference between positive and negative information from environment.

In sum, expression is one way to acquire information from another person, but a positive one may accelerate these discrimination performances and may be modulated by the contrast of information. Other types of discrimination tasks exist and result in associations that are equivalent to classical conditioning, where perceivers watch different types of scenes that are repeatedly paired with eigenfaces. However, it is an unresolved question whether other types of social learning have effects on cognitive processing.

Finally, our findings contribute to the growing scientific evidence that cognitive processing in discrimination is not sufficient for current experiences. The environmental influences are crucial in making sense of the discrimination with "late" perceptual brain areas helping to modulate "early" areas [19]. Our results contribute a new avenue to this field by demonstrating that affective information acquired through scene influences vision so that what we know about someone through their expression may be affected not only by the expression itself but the context within which it is perceived.

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