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Research Paper: Using Signal Detection Theory to Investigate the Impact of Mood Induction on Emotional Information Processing in High BAS/BIS Individuals

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ABSTRACT

Objective: The main objective of this study was to investigate the explicit memory bias in the people with high BAS/BIS sensitivity in the different manipulated mood states.

Methods: By using purposive sampling method, seventy-four participants (undergraduate students) were selected based on z-scores of 480 using the Carver and White's BAS/BIS scale. They were distributed as: 24 with high BAS sensitivity, 25 with high BIS sensitivity and 25 as the control group. Data were gathered in the framework of quasi-experimental design. All the subjects were presented with emotional words for memorization. Then, the participants in each group were randomly assigned to either a sad or a happy mood induction prior to performing a recognition memory task. Reaction Time (RT), response bias (ß) and sensitivity (d') for the emotional word recognition was calculated using the signal detection theory.

Results: Reaction time for recognizing the negative words in the sad mood condition was shorter in the high BIS sensitivity group, relative to the high BAS sensitivity group and controls. No significant differences were observed for sensitivity (d'), neither between groups nor within the control. However, lower ß for negative words was observed in the high BIS sensitivity group only.

Conclusion: Results indicated that individuals with high BIS sensitivity use more liberal strategy for the negative word recognition.

1. Introduction

Gray's Reinforcement Sensitivity Theory (RST) (Gray, 1987; Bijttebier, Beck, Claes & Vandereycken, 2009) is a biological model for personality that consists of Behavioral Approach System (BAS) and Behavioral Inhibition System (BIS). According to this theory, the defining feature of BAS is impulsivity and that of the BIS is anxiety. In Gray's theory, BAS is sensitive to the signals of reward and non-punishment, causing an increase in the individual's behavioral activity to attain such stimuli. In con-

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trast, BIS is sensitive to the signals of punishment, lack of reward and also recentness, causing a decline in the individual's behavioral activity to attain these stimuli. Gray and others (Carver & White, 1994; Watson, Wiese, Vaidya & Tellegen, 1999; Yan & Dillard, 2010) have shown that BAS and BIS are associated with positive and negative mood, respectively.

Some studies have pointed towards the fact that emotional processing is tied up with current mood states and personality traits (Rusting, 1999; Zelenski & Larsen, 2002). Furthermore, studies have established that personality traits associated with moods and temperamental states aid in predicting selective processing of emotional information (Gomez & Gomez, 2002; Rafienia, Azadfallah, Fathi-Ashtiani, Rasoulzadeh-Tabatabaiei, 2008). In the same context, the mood-congruency hypothesis (Bower, 1992) argues that the positive mood conditions are associated with inclination towards perception of, attention to and interpretation of the pleasing emotional information and also with the retrieval of pleasing materials. In contrast, negative moods are linked with inclination towards perception of, attention to and interpretation of the unpleasant emotional information and with retrieval of the unpleasant materials. One theory influenced by Bower's mood congruency hypothesis is the network theory of affect, on the basis of which an emotion is represented by an emotional node related to it. Basically, the emotional node is a complex cognitive network composed of cognitions, materials and memories which is closely associated with emotion. When a certain emotion is experienced, the emotional node associated with it gets activated, evoking past memories and their attached beliefs and impressions. Some studies point to evidence in favor of processing that is congruent with mood (Rafienia et al, 2008).

The trait-congruency hypothesis (Rusting, 1999) argues that emotional processing is under the influence of particular personality traits; personality traits make the individual likely to process emotional information consistent with their traits. In line with this hypothesis, studies have established that the activated pleasant affect and the high BAS sensitivity are associated with the processing of pleasant emotional information; in contrast, stress and high BIS sensitivity are associated with processing of unpleasant emotional information (Gomez & Gomez, 2002). Furthermore, there was evidence in support of the fact that people with higher stress vulnerability respond more quickly to negative emotional cues in comparison with those under lower stress vulnerabilities (Eysenck & Byrne, 1994). Moreover, when presented with both intimidating and non-intimidating words, these people recognize the intimidating remarks more quickly (Mogg, Mathews& Eysenck, 1992). These people also recognize and retrieve negative words more than neutral ones (Eysenck & Byrne, 1994).

Results of other studies, in line with the current study, shows that the effect of only one mood variable or personality trait on cognitive processes have been investigated, making it difficult to determine the role of the interactions between the traits and moods state in the processing of the emotional information. Although some evidence have been gathered from research, into the effect of interactions between personality and mood on cognitive processes (Gomez & Gomez, 2002; Rusting & Larsen, 1998; Zeleneski & Larsen, 2002), the findings, therefore, are inconsistent with one another. This disparity is partly due to the mood in question, i.e., natural mood as compared to the manipulated mood and partly due to the type of the tasks being performed with the participants in the study. A study of the substance of Gray's theory and the trait-congruency hypothesis points to the conclusion that the personality traits associated with BAS and BIS sensitivity, selectively processed the pleasant and unpleasant emotional information, respectively. On the other hand, based on the mood-congruency hypothesis some studies maintain that temporary moods state also play a role in the rate of processing positive or negative emotional information. So the question one can pose in this regard is if it can temporarily manipulate the moods state, moderate the association between personality trait and emotional processing? The main objective of the present study is to investigate–within the mold of mood-congruency and trait-congruency hypotheses–the explicit memory bias in the people with high BAS and BIS sensitivity in different manipulated moods state.

2. Methods

Participants were comprised of 527 undergraduate students, who completed the Persian version of the Carver & White's BIS/BAS scale (1994). Forty-seven participants were excluded due to left-handedness. To begin with, the raw scores of 480 right-handed students were converted into standard (z) scores. Next, by using purposive sampling method, on the basis of the distributed scores, as the high BAS sensitivity group (24 subjects:12 male and 12 female, mean age=22.1±2.1), only those ones were selected whose standard (z) scores on the scale of BAS exceeded +1.5 and on the scale of BIS was lower than -1.5. Subjects who scored above +1.5 on the BIS scale and lower than -1.5 on the BAS scale were selected as the ones with high BIS sensitivity (25 subjects:12 male and 13 female, mean age=21.4±1.5). As to

the control group (25 subjects: 11 female and 14 male, mean age=21.5±1.6), the selection criterion was such that the people whose standard (z) score lay between -0.5 and +0.5 on both the BIS and BAS scales (z±0.5) were considered as the control group (that is, people who passed as average on both scales). The mean and the standard deviation of the scores on the BAS and BIS scales separately for each group were following: high BAS sensitivity group [47.28(1.33), 18.24(3.04)], high BIS sensitivity group [38.84(2.79), 25.28(1.36)] and control group [41.24(0.77), 20.84(0.85)].

Emotion and moods state were measured using the Self-Assessment Manikin (SAM), an affective rating system devised by Lang et al. (1995). The paper-and-pencil version of SAM is composed of three sets of five figures (manikins), each one corresponded to one of the three dimensions of the PAD model of affect (Pleasure, Arousal and Dominance). Figures depicted valence range from a widely smiling, happy manikin (pleasant pole) to a frowning and unhappy one (unpleasant pole), going through a middle neutral stance. In this way, participants indicated their emotional status by placing an "X" over any of the five figures in each scale or between any two figures, which resulted in a 9-point rating scale (Nabizadeh Chianeh, Vahedi, Rostami, & Nazari,, 2012).

To induce negative and positive moods we used clips which were combined with emotional pictures and musical excerpts. Emotional pictures selected from the International Affective Picture System-IAPS (Lang, Bradley& Cuthbert, 1995). The negative emotional pictures included anger snakes, traffic accidents, miserable people, crying children, cemeteries and drug addicts. In contrary, for induction of the positive mood, we selected positive emotional pictures which included happy babies, family idylls, landscapes and athletes involved in sports. We selected 40 pictures for the negative mood condition and 40 pictures for the positive mood condition. Based on the findings of Baumgartner, Esslen & Jancke (2006), we paired the IAPS pictures with congruent music excerpts which maximized the emotional effect of the slides. While performing the picture viewing task, participants heard Iranian pleasant and unpleasant musical excerpts that induced the appropriate emotional state (happy, sad) corresponding to the emotional pictures. We tested this mood induction procedure in a pilot experiment. Thirty-two students (different from the sample under study) were asked to rate the emotional content of clips using the SAM picture, on the 9-point scale (1=sad, 9=happy). The mean and standard deviation were 7.81(1.35) and 2.18(1.54) for positive and negative conditions, respectively. The mood induction procedure lasted for 4 min.

In order to investigate the processing of emotional information, an explicit memory test was used. The prompt used in this study consisted of 90 emotional words (30 positive, 30 negative and 30 neutral words). The initial word list (182 words) was based on commonly used words in the Persian Language. 101 students (different from the sample under study) were asked to rate each word in terms of its emotional valence using the SAM picture, on the 9-point scale (1 represents fully happy and 9 totally sad). Words with the mean of 3 and lower were considered positive words, above 7.5 negative and in between 4.25 and 5.75 neutral. From this, 109 words were selected according to this criterion (35 positive, 36 negative and 38 neutral). Since the length of the word and its type has an effect on its recollection and retrieval (Eysenck and Byrne, 1994), the words in all the three-word lists were tallied in terms of length and type. Thus, 90 words (30 words matched for each list) were selected. The mean and standard deviation for 30 negative words were 8.11(1.19); for 30 positive words were 2.18(1.51) and for 30 neutral words were 4.55(1.47). The ANOVA test revealed the differences to be significant ($F=2257.75$, $P<0.0001$). Cronbach's alpha was 0.87, 0.88 and 0.83 for negative, positive and neutral words, respectively.

Explicit memory was measured through the recognition method. At this level, 45 words (15 neutral, 15 negative and 15 positive) were randomly selected from the 90-word list. The 45-word list, known as the 'old list,' was presented to the subjects for the sake of memorization. Then, the 90-word list, known as the 'new list,' was presented to the subjects for the sake of recognition. The presentation of words in the old and new word lists was carried out by a computer program. Each of the 45 words of the old list appeared for 2500 milliseconds (ms) on the computer screen. The inter-stimulus-interval was 1500 ms. Each of the 90 words in the new list appeared for 600 ms on the screen. The inter-stimulus-interval ranged from 700 to 1100 ms (average 900 ms for each word).

Participants were tested individually. They were contacted one day prior to the experiment according to a pre-scheduled timetable and were asked to come to the psychology lab for cooperation in the second phase of the project. All the experiments were conducted over the period of 9 a.m. to 3 p.m., each lasting for approximately 15 minutes. For all participants, the informed consent was obtained.

After establishment of the initial relationship with the participants they were provided with the requisite explanations as they sat before the computer screen. Next, the experiment was conducted in the following steps: To begin with, the basic mood states of the participants were assessed by the SAM pictures. The 45 emotional words (old list) were presented randomly and one-by-one to the participants through the computer screen. They were asked to commit the words to their memory with the utmost possible care. At this step, where mood states were manipulated, the participants watched the sad or the happy clip for four minutes. Each participant was randomly assigned to either a group that induced happy moods or other with sad ones. Half of the participants in each group experienced positive mood while the other half experienced negative mood. After mood induction, the mood states of the participants were re-examined with the SAM pictures. This was done to understand the effect of the induced mood. Eventually, the words in the 90-word list were presented one-by-one and randomly on the computer screen for the participants to recognize. Here, they were asked to push the response button in the quickest possible time as soon as they observed the words from the previous list.

All of the participants provided their informed consent. The study was approved by the research committee of the Azad University of Tabriz and was conducted in accordance with the Declaration of Helsinki.

In this study, we applied signal detection theory (Green & Swets, 1966) to investigate the underlying psychological processes of the emotional word recognition. Participants' performance can be decomposed due to sensitivity (discriminability) and response bias. The sensitivity or d-prime (d') refers to the participants' ability to differentiate between stimulus 1 and stimulus 2 (ability to distinguish target words from the non-target or the distractor words). A larger d' means a better ability to recognize the target words from other words. Response bias (β) reflects the participant's general tendency to define an ambiguous stimulus as a target. The β can range from being very conservative to avoid misses, to being liberal to avoid making false alarms. High β signifies a strict criterion (conservative); the subject is biased towards saying "no" (judging that any word is a non-target word). d' and β were derived from the behavioral model of the signal detection (Green & Swets, 1966; Rottello, 2017).

D-prime (d'), response bias (β) and Reaction Time (RT) were examined as dependent variables and these variables entered into a 3×2×3 repeated measure analysis of variance, with group (high BAS sensitivity vs. high BIS sensitivity versus control group) and mood condition (happy versus sad) as the between-subject factor, and emotional word (positive versus negative versus neutral) as within-subject factors. Post-hoc analysis was performed using Fisher's Least Square Difference test when ANOVA yielded significant.

3. Results

Reaction time

The mean and the standard deviation of the reaction times are presented in Table 1. The main effect of the emotional word on the reaction time was significant [$F_{(2,136)}$=13.32, P<0.001]; neutral words (615.96±54.34) were greater than negative words (599.94±60.66), which were greater than the positive words (583.93±56.80). There was a significant interaction effect of emotional word × mood condition [$F_{(2,136)}$=5.63, P<0.01] and emotional word × mood condition × group [$F_{(4,136)}$=2.44, P<0.05]. No other

Table 1. Mean and standard deviation of reaction times

Groups	Mood Conditions	Emotional Words		
		Neutral	Negative	Positive
BAS	Sad	621.64(51.5)	634.5(56.1)	603.58(50.6)
	Happy	612.12(72.6)	599.73(72.6)	553.19(58.2)
BIS	Sad	609.03(25)	625.09(49.7)	596.39(66.01)
	Happy	636.15(60.5)	625.09(59.5)	586.03(71.1)
Control	Sad	614.59(53.9)	600.27(42.7)	593.26(29.6)
	Happy	617(63.7)	595.65(49.6)	571.17(51)

Table 2. Mean and standard deviation of d-prime (d′)

Groups	Mood Conditions	Emotional Words		
		Neutral	Negative	Positive
BAS	Sad	1.6720(.8436)	1.2840(0.5428)	1.6994(0.7255)
	Happy	1.9167(1.3719)	1.4131(0.4424)	1.4237(0.8194)
BIS	Sad	1.9093(1.2506)	1.4887(0.7583)	1.7581(0.9664)
	Happy	1.7963(1.0179)	1.2780(0.4469)	1.7846(0.7011)
Control	Sad	1.8237(.6273)	1.1522(0.5008)	1.6296(0.4583)
	Happy	1.5017(.5554)	1.0100(0.4991)	1.2636(0.4016)

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significant main effects or interactions were observed. The 3-dimensional interaction was explained by the fact that the reaction time differences between groups were statistically significant in the sad mood condition [F(4, 68)=4.34, P<0.01] but not in the happy mood condition. Further, post hoc analysis revealed that the reaction time for recognizing negative words, in the sad mood condition, was significantly (P<0.01) shorter in the group with high BIS sensitivity, compared to the high BAS sensitivity group and controls.

D-prime (d′)

Table 2 presents the mean and standard deviation of the d'. The main effect of emotional word on the d' was significant [$F_{(2,136)}$=4.59, P<0.001], exhibiting that discriminability was lowest for negative words (1.2670±0.5515) as compared to positive (1.5904±0.7057) and neutral words (1.7634±0.9595) in all the groups. No other significant main effects or interactions were observed.

Response bias (β)

The mean and standard deviation of the β values are presented in Table 3. The main effect of emotional word on the β was significant [$F_{(2,136)}$=4, P<0.05]. This suggested that the β value was lowest for negative words (1.1206±0.4818), as compared to the positive (1.3301±0.6350) and the neutral words (1.3292±0.6863) in all the groups. Emotional word × group interaction effect was significant [$F_{(2,136)}$=2.64, P<0.05]. The interaction analysis showed that there were significant between-group differences in recognition of the negative words [$F_{(4,68)}$=6.95 P<0.05] but no difference in the recognition of positive or neutral words. Further post hoc analysis revealed that the β value for negative words was significantly (P<0.01) lower in the group with high BIS sensitivity, compared to the high BAS sensitivity group and controls. No other significant main effects or interactions occurred, based on the β values.

Table 3. Mean and standard deviation of response bias (β)

Groups	Mood Conditions	Emotional Words		
		Neutral	Negative	Positive
BAS	Sad	1.2031(0.5444)	1.1316(0.4168)	1.1938(0.4852)
	Happy	1.1883(0.8540)	1.4509(0.6868)	1.1812(0.3575)
BIS	Sad	1.3155(0.6324)	0.6754(0.2024)	1.2020(0.7030)
	Happy	1.3176(0.7998)	0.9916(0.2003)	1.3251(0.7434)
Control	Sad	1.4382(0.4385)	1.2688(0.5131)	1.6231(0.6771)
	Happy	1.4961(0.8242)	1.2354(0.3986)	1.4571(0.7324)

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4. Discussion

The objective of this study was to investigate the effect of mood induction on the processing of emotional information with regards to the brain-behavioral systems. The current study drew upon the participation of three groups of subjects: individuals with high BIS/BAS and a control group. We placed three cognitive dimensions under scrutiny (reaction time, response sensitivity and response bias), based upon the signal detection theory.

The results pointed to the fact that subjects with high BIS sensitivity, when exposed to sad mood induction, recognized the negative emotional words significantly faster than individuals with high BAS sensitivity and the control group. However, no significant difference emerged with regards to the reaction time of the emotional words in the BAS and control groups. Since the defining characteristic of BIS is anxiety, the findings of the previous studies indicate that anxious people retrieve and recognize more negative than neutral words and respond faster to the negative emotional cues (Eysenk & Byron, 1994; Heeren, Maurage, Philippot, 2015; Sheldon & Donahue, 2017). Moreover, these findings are in line with the parts of some researches (Gomez & Gomez, 2002; Corr, 2002) which indicated that the anxious people and individuals with high BIS sensitivity process unpleasant emotional cues in a better way, but does not match up with another part of their findings that argued the people with high BAS sensitivity and impulsivity trait process pleasant emotional cues in a better way. Thus, the findings of the current study could only lend support to the Rusting's trait-congruency hypothesis (1998) and the Bower's mood-congruency hypothesis (1991) in relation to the BIS group.

The sensory process and the cognitive decision process are two broad aspects of the psychological processes involved in the decision making (Krantz, 1969; Rottello, 2017). The signal detection theory provided two separate measures for performance in the decision making. These measures provided useful information about two aspects of the decision making: sensory process and cognitive process. The sensory process is measured by d-prime. It determines how well the individuals are able to select the target stimuli while avoiding the non-target ones. The second measure, response bias (β), was related to the cognitive aspect of the decision process. β reflected the tendency of individuals, their bias towards, to make a certain decision with the information they have received from the sensory process (Rottello, 2017). For instance, signal detection theory has been utilized for investigating the relationship between working memory capacity and emotion perception (Lynn et al., 2016). Interestingly, response bias of the sub-clinical paranoia subjects (Westermann & Lincoln, 2010), hallucination-prone individuals (Moseley, Smailes, Ellison, & Fernyhough, 2016) and expert individuals (Nazari & Zamani Asl, 2015) was revealed by the signal detection theory method.

As concerned with the d-prime, the findings of the current study suggested that the subjects with high BIS/BAS sensitivity and the control group in happy and sad mood states had equal sensitivities to the recognition of the different emotional words. That is, participants of all three groups exhibited equal sensitivity to the stimuli both congruous and incongruous with their moods. However, β for sad stimuli in the BIS group was significantly lower than in the other two groups. A high β score indicated that the subject's conservative leaning in response to and recognition of the stimulus, while a low β pointed to the subject's dismissive and off-hand way to deal with the stimulus. This meant that individuals with a high BIS sensitivity entertain lax and dismissive criteria in the recognition of sad stimuli (i.e., they answer affirmatively, more often when recognizing the sad stimuli). It followed that the BIS group not only exhibited bias in the explicit memory with regards to stimuli which are "congruous with mood," but they also acted differently from the other groups when dealt with sad stimuli.

In this study, subjects with high BIS sensitivity, as opposed to the BAS and control groups, exhibited bias in response to the negative emotional stimuli in terms of the reaction time and β. In order to elucidate these findings, it may be argued that, in line with Gray's theory, a high BIS sensitivity was represented as the signs of punishment. This sensitivity to punishment could also be surfaced in the cognitive processing of emotional stimuli, such that BIS subjects' higher sensitivity to signs of punishment probably lead them to draw upon more resources to process these signs and, therefore, processed more negative emotional information (Rusting, 1999). Processing which is congruous with trait could also be the result of stable schema related to particular emotions to which BIS subjects were prone. On the other hand, according to Bower's emotional network theory (1991), the cognitive structure of BIS subjects was such that they can have more extensive retrieval networks for the negative emotions. As a result, the negative mood conditions easily activated the links between these networks, spreading fast to emotional nodes with similar emotional values. This, in turn, affected the memory and judgment congruous with emotion (Parrot & Sabini, 1990; Westermann & Lincoln, 2010). Thus, the findings of the present study

lend support to the assumption that BIS is correlated with the processing of unpleasant emotional information. They also open up an insightful window onto Gray's underlying assumptions, at least with regards to the Behavioral Inhibition System (BIS). Gray proposed that BIS activity does not merely lead to inhibitive behavior and negative mood; it also caused the retrieval and expansion of unpleasant emotional material from the memory (Rusting & Larson, 1998; Sheldon & Donahue, 2017).

There are some issues to be considered in interpreting the results of this study. The findings have emerged from right-handed students, so it may not be possible to generalize them to the left-handed subjects and non-students. On the other hand, the results were from the limited dimensions been studied for the cognitive domain (attention bias); thus, it was not readily clear if one could generalize them to the other dimensions of that domain (interpretation and judgment). Further, dimensions of the cognitive domain in relation to BAS and BIS systems could have been investigated, in order to attain a more profound and broader understanding of the relationships among personality, emotion and cognition. In relation to the emotional processing in the subjects, a proposal for further research would be to look at the neutral mood too.

Our results indicated the interactive effects of the personality, mood and information processing. We postulated memory bias in people with high BAS and BIS sensitivity as a function of their mood. In other words, individuals with high BIS sensitivity adopted a more liberal strategy for the negative word recognition, thus trait- and mood-congruent response bias.

Ethical Considerations

Compliance with ethical guidelines

The study was approved by the research committee of the Azad University of Tabriz and was conducted in accordance with the Declaration of Helsinki.

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Conflict of interest

The authors have no conflict of interest to declare.

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