Predictive Bias Towards Neutral Stimuli in Non-Clinical Anxious Individuals

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Abstract: The relationship among predictive bias towards neutral stimuli, trait anxiety and gender in non-clinical individuals is studied. According to the scores on Trait Anxiety Inventory (TAI), 31 individuals are randomly selected from the highest 20% scorers as the high anxiety group, and 31 individuals from the lowest 20% scorers as the low anxiety group. Three types of stimulus situations are designed in the experiment, that is, 100% predictable, 50% predictable and unpredictable stimulus situations. MANOVA, which is performed on the reaction of high/low anxiety groups under three stimulus situations, shows that significant differences exist between high anxiety and low anxiety group under the 50% predictable and unpredictable conditions. Independent sample T test shows significant gender differences on predictive bias exist only in high anxiety group. Results of this study show that predictive bias towards neutral stimulus can be found in non-clinical anxious individuals and is significantly correlated with trait anxiety. In addition, predictive bias is more evident in high anxious female.

Keywords: Non-clinical anxious individuals, predictable, unpredictable, predictive bias.

1. INTRODUCTION

Studies found that rats shocked under unpredictable situation showed diffuse gastric ulcer, while those who received the same amount and intensity of shock under predictable situations showed significantly reduced gastric ulcer symptoms [1, 2]. Grillon [3] studied healthy group and found that compared with predictable aversive stimulus, individuals showed more prominent physiological reaction to unpredictable aversive stimulation. Grillon [4] reached a consistent conclusion when studying post-traumatic stress disorder (PTSD) patients and panic disorder (PD) patients: Compared with the predictable aversive stimulus, PTSD and PD patients showed a higher anxiety level to the unpredictable aversive stimulus. Both animals and humans show predictive bias to aversive stimulus [5, 6]. In other words, animals and humans prefer predictable aversive stimulus which are less harmful to individuals' psychology, physiology and behavior, because people have psychological and physiological emergency preparedness [7-10]. Besides, unpredictable aversive events lead to a sustained state of anxiety and a chronic expectation of the unconditioned stimulus [11].

What was the reason for individuals' predictive bias? Safety-signal hypothesis regards when an individual is under a predictable situation, he can predict threat stimulus by clues. No clues means no threat stimulus, suggesting that present situation is safe. On the contrary, when an individual is under an unpredictable situation, he will be anxious or in an anxiety expectation because of no clues, and show higher levels of anxiety and stronger physiological reaction [12]. The hypothesis was used by many scholars to explain individuals' predictive bias to aversive stimulus. However, some studies found that predictive bias to positive stimulus also existed in animals and humans [13, 14]. Therefore, Safety-signal hypothesis cannot explain this phenomenon. Veening *et al*. [15] studied the neural basis of panic stimulation when individuals were dealing with predictable and unpredictable situations with fMRI technology. The findings showed that two situations are adjusted respectively by different brain regions. Unpredictable panic is mainly adjusted by the hippocampus and its related functional areas such as the nucleus

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accumbens (NAcc) and the anterior cingulate cortex (ACC), while predictable panic is mainly adjusted by the central and dorsolateral part of the amygdale. Therefore, individuals' reactions to unpredictable and predictable panic or threatening stimulus are adjusted by different neural mechanisms.

This predictive bias is universal to clinical anxious individuals. Predictability is generally regarded as the core characteristics of anxiety and anxiety disorder [16-18] and the key feature of anxiety disorder [19]. Moreover, the predictability of upcoming aversive events during fearful anticipation is a key feature for the distinction between transient phasic and sustained tonic fear [20]. Correlational researches show that PTSD or PD patients will have a higher level of anxiety and a more significant predictive bias when they are exposed to negative stimuli, such as aversive or panic stimuli, under unpredictable situation [4]. One of the questions that we are researching is whether the predictive bias exists in non-clinical anxious individuals? Whether the predictive bias exists between different genders? Grillon [3] found that women, compared with men, showed a significantly high level of panic to unpredictable stimuli. Lejuez *et al*. [6] studied the question with the panic related paradigm and found that individuals' predictive bias to aversive stimuli would vary with the anxiety sensitivity and that women show more obvious predictive bias than men. Therefore, gender will be treated as a variable in our research to study whether the predictive bias exists between men and women in non-clinical anxious individuals.

The second question that we are researching is whether people also have predictive bias to neutral stimuli. Previous studies found that people have predictive bias to negative stimuli, such as aversive stimuli. Grillon [3] used two types of aversive stimuli in the experiment, the electric shock which was more aversive and the air blast which was less aversive. Results showed that in shock group the participants had a higher level of anxiety in an unpredictable situation than a predictable situation, while in the blast group significant differences haven't been found. He found that only when the stimuli were aversive enough, unpredictable stimulus situations would lead to sustained levels of anxiety. Some researchers also used other types of aversive stimuli, such as white noise, 2000Hz sound, siren sounds and women's shriek. In addition, the predictive bias to positive stimuli was also found by some researchers [13, 14]. If the predictive bias is a stable psychological state, is it also stable to neutral stimuli ? Compared with predictable situations, will the response delay to the neutral stimuli occur in unpredictable situations? The researches will provide more plentiful and favorable evidences to the researches of predictive bias.

The purpose of this study is to investigate the predictive bias of non-clinical anxious individuals to neutral stimuli in different levels of predictability and to analyze whether the predictive bias exists between different genders.

2. METHODS

2.1. Participants

280 college students were randomly selected and completed trait anxiety Inventory (TAI). 261 questionnaires were collected, with the recovery rate of 93.57%, among which 249 questionnaires are valid. According to the scores of TAI, 31 individuals are randomly selected from the highest 20% 50 scorers as the high anxiety group (T-AI = 54.84±5.91), and 31 individuals from the lowest 20% 50 scorers as the low anxiety group (T-AI = 31.13±2.46). The average age of the participants is 20.87±1.51. All participants, including 29 men and 28 women, reported normal or corrected-to-normal vision, no color blindness and color weakness, no hand movement disorders.

2.2. Materials

Trait anxiety inventory (TAI). It is a subscale of state-trait anxiety inventory (STAI) developed by Spielberger. The inventory, a 5-point rating scale, consisting of 20 statements, is used to assess emotional experiences under normal circumstances. TAI was revised by Zheng Xiao-hua in Chinese. The test-retest reliability of the inventory is 0.90.

Stimulating pictures: blue squares and yellow triangles are used for 100% predictable group and 50% predictable group, while green circles and yellow triangles are used for unpredictable group. Among which blue squares are used as clues pictures.

Sound material: 1000 Hz neutral sound without emotional color. The white noise was processed with Cool Edit, a kind of sound processing software, into 1000 Hz sound. Sound parameters include: frequency 44100 Hz, double track, sampling number 16. Sound duration of 1s is the target stimulus of this experiment.

2.3. Design

The 2 (gengder: male and female) × 2 (types of anxiety: high and low) × 3 (stimulus situation: 100% predictable, 50% predictable and unpredictable) three factors mix design is adopted in the experiment. Gender and types of anxiety are the between-group factor. The within-group factor is stimulus situations.

2.4. Procedure

Firstly, a red fixation point "+" will be popped up on the computer screen for 500ms. Then, a picture will be presented for 5s. When the picture disappears, another picture of "small horn" appears, during which the target sound will be played or not played for 1s. The sound stops when participants press the button. The flow chart of the procedure sees Figure **1**.

In 100% predictable situation, if the blue square appears, the target sound will follow, while if the yellow triangle appears, no target sound will follow. In 50% predictable situation, if the blue square appears, there will be a 50 percent chance the target sound will appear and 50 percent chance it won't, while if the yellow triangle appears, no target sound will follow. In the unpredictable situation, any picture (that is, the green circle and the yellow triangle) will be followed by target sound or no target sound.

Participant should press the button "F" as soon as possible when he hear the target sound and press "J" when he doesn't hear it. It is clearly indicated in the instructions that the participant will press the button only when the picture of "small horn" appears. In addition, in order to avoid current experimental conditions being confused by participants we remind them at the bottom of the screen with the hints like "Target sound must appear after the blue square!"(100% predictable group), "Target sound may appear after the blue square at a probability of 50%!"(50% predictable group) or "Target sound may appear after any graph!" (unpredictable group) in the whole experiment process.

The whole experiment is mainly divided into three parts or three stimulus situations. Each part includes 8 practice tests and 72 official tests, lasting for 8 to 9 minutes or so. Therefore, the whole experiment includes 24 practice tests and 216 official tests, lasting for 30 minutes. When each part of the experiment ends, participants are required to close their eyes for 2 minutes.

The experiment should be completed individually. The participant's eyes are parallel to the center of the monitor and the distance between them is 60cm.

The experimenter will confirm the details of the experiment by phone with 62 participants, including place, time, specific requirements and the remuneration, etc. When participants come into the laboratory, the experimenter will tell the experiment tasks to them again. According to the principle of voluntariness, participants have the rights to quit at any stage in the progress of the experiment.

2.5. Data Analysis

The data will be reorganized before the formal data analysis. The data will be deleted when participants press the wrong key or when the reaction time is beyond 2 standard deviations from the mean. In previous related literature, correct rate is generally not be researched as a dependent variable. Therefore, the reaction time will be the only dependent variable of this study.

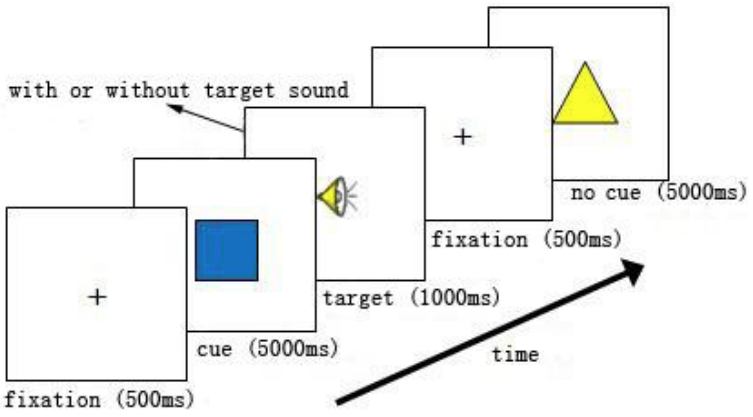

Figure 1: experiment procedure.

Table 1: Reaction Time of Different Anxiety Groups in Different Stimulus Situations (ms)

	Low Anxiety Group						High Anxiety Group					
	Male			Female			Male			Female		
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
100% predictable	241.12	33.65	14	263.78	44.11	13	252.27	58.17	15	280.98	81.16	15
50% predictable	363.52	28.41	14	396.77	41.67	13	420.67	100.62	15	507.89	109.02	15
unpredictable	404.82	59.27	14	431.07	47.31	13	447.84	84.82	15	530.15	106.18	15

3. RESULTS

In data processing, if the participants react wrongly or if the reaction time is beyond 2 standard deviations from the mean reaction time, the abnormal data will not be included in the data analysis. The average error rate of the experiment is 3.52% and the standard deviation is 2.19. The data of five participants were deleted because of the high error rate (The error rates are 9.72%, 8.80%, 7.95%, 8.80% and 9.26% respectively, which are beyond 2 standard deviation from the mean). Thus, among the remaining 57 participants, 30 participants were classified as high anxiety group, including 15 men and 15 women, while 27 participants were classified as low anxiety groups, including 14 men and 13 women. The differences of the error rates and abnormal values between two groups are not significant (See Table **1**).

Variance analysis found that the main effect of anxiety types [F (2, 53) = 11.29, p < 0.01] and stimulus situations [F (2, 53) = 309.66, p < 0.01] were significant. The main effect of gender was also significant, F (2,53)=7.74, p<0.01. There was no significant interaction between anxiety type, gender and stimulus situation, F (2,53)=1.43, p=0.24>0.01. Significant interaction between gender and stimulus situation was also not found, F (2,53)=2.44, p=0.09>0.01.

There was significant interaction between anxiety type and stimulus situation, F (2, 53) = 9.87, p < 0.01). Here, we focused on this significant interaction and made a deeper analysis on it. In 100% predictable, 50% predictable and unpredictable situations, high and low anxious individuals showed significant differences. Further analysis of the simple effect (see Figure **2**) found that individuals in low anxiety group showed significant differences among 3 stimulus situations, F (2, 54) = 74.61, p < 0.01. The reaction times of low anxious individuals in 50% predictable and unpredictable situations are much longer than that in 100% predictable situation. Individuals in high anxiety group also showed significant differences among 3 stimulus situations, F (2, 54) = 167.83, p < 0.01. The reaction times of high anxious individuals in 50% predictable and unpredictable situations are much longer than that in 100% predictable situation. However, in 100% predictable situation, high and low anxious individuals did not show significant differences, F (1,55)=0.89, p=0.35>0.01; in 50% predictable situation, they showed significant differences, F (1,55)= 13.90, p<0.01, and the reaction time of high anxious individuals is much longer than that of low anxious individuals; in unpredictable situation, they showed significant differences, F (1,55)= 10.35, p<0.01, and the reaction time of high anxious individuals is much longer than that of low anxious individuals.

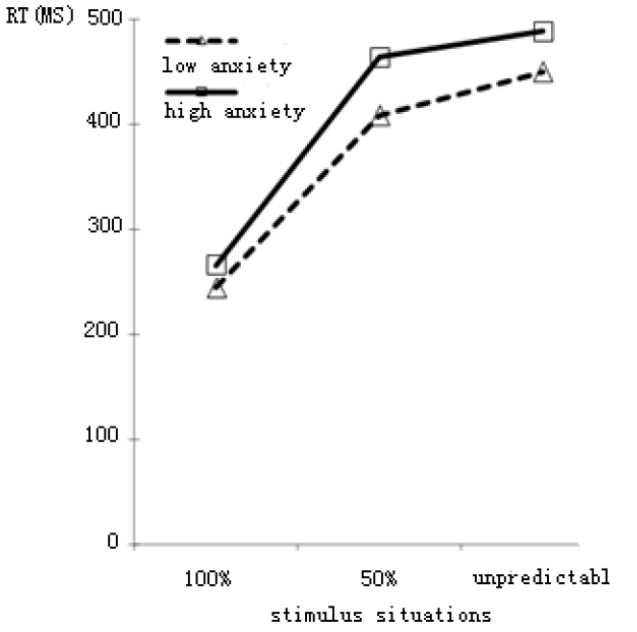

Figure 2: The RT under three stimulus situations of high and low anxiety group.

To examine the gender effect of predictive bias, a comparison of gender (RT of male and female) by 100% predictable situation, 50% predictable situation, and unpredictable situation was conducted through independent sample T-test. In 100% predictable

Table 2: Reaction Times of Different Genders in Different Stimulus Situations and the Result of Independent Sample T-test

	Male (N=29)	Female (N=28)	*t*	*P*
100% predictable	243.44±47.23	269.42±66.07	-1.71	0.09
50% predictable	410.32±86.28	467.01±97.90	-2.32	0.02**
unpredictable	444.31±80.90	498.43±93.61	-2.34	0.02**

situation, no significant differences existed between male and female in general; In 50% predictable situation, significant difference existed between male and female in general [t (55)=-2.32, p=0.02<0.05]; In unpredictable situation, significant difference existed between male and female in general [t (55)=-2.34, p=0.02<0.05]. The result was shown in Table **2**.

A comparison of gender (RT of male and female) by low anxiety and high anxiety was also conducted through independent sample T-test. In low anxiety group, no significant differences existed between male and female in 100% predictable, 50% predictable and unpredictable situations, t (25)=-1.56, p=0.13>0.05; t (25)=-0.84, p=0.41>0.05; t (25)=-0.77, p=0.45>0.05, respectively. However, in high anxiety group, no significant differences existed between male and female in 100% predictable situation, t (28)=-1.11, p=0.28>0.05, while significant differences existed between male and female in 50% predictable and unpredictable situations, t (28)=-2.28, p=0.03<0.05, t (28)=-2.35, p=0.03<0.05, respectively.

4. DISCUSSION

Based on our results, we can draw a conclusion that the predictive bias of non-clinical individuals to neutral stimuli is strongly associated with trait anxiety. Specially, females with high trait anxiety have more predictive bias.

4.1. Predictive Bias of High and Low Anxious Individuals

The experimental results showed that there was obviously sexual difference in the reaction time of high and low anxious individuals to three kinds of stimulus situations. In 100% predictable situation, no significant differences existed between high and low anxiety groups. In 50% predictable and unpredictable situations, significant differences existed between them. The reaction time of high anxious group was significantly slower than that of low anxious group. The result showed that individual's predictive bias is associated with his trait anxiety, and the predictive bias of high anxious individuals is more apparent. This result is consistent with Lejuez's study [6].

Seligman and Binik [12] explained individual predictive bias to aversive stimulus with the safety-signal hypothesis. In predictable situations, individuals can predict threats through clues or signals. So as long as the signals of danger do not appear, individuals will be in a safe period and can avoid staying in a state of anxiety for long. In unpredictable situations, however, aversive events cannot be predicted through signals. Individuals are likely to be immersed in the lasting anxiety expectation because the threatening stimulus may appear at any time. Thus, the behavioral and physiological reactions of the participants will also be more intense. In other words, temporal unpredictability would elicit heightened defensive responses compared to temporal predictability [21]. Grillon [4] holds that predictability is a basic controller of anxiety and the ability to predict aversive events can reduce individual anxiety reaction. Persistence feature of anxiety is aroused by the expectations of next startling stimulus with no signals. Felicia *et al*. [22] found unpredictability in the environment may increase an individual's neural response to errors—an effect that may mediate increases in anxiety and sensitivity to threat.

As a result, the predictive bias of high trait anxious individuals towards neutral stimulus is significantly more apparent than that of low trait anxious individuals. We can explain it as the following: In 100% predictable situation, individuals can accurately determine whether target stimulus will appear through the clues. During the whole stage, individuals needn't speculate and expect whether target stimulus will appear or not, which won't cause individuals' persistent anxiety. However, in 50% predictable and unpredictable situations, individuals cannot accurately judge whether target stimulus will appear or not in spite of the emergence of the clues. Especially in unpredictable situation, individuals will anticipate during the whole process. In the stage of expectation and waiting, compared with

low anxious ones, high anxious individuals are more likely to arouse anxiety and mood swings. So the reaction of high anxious individuals to the target stimulus will be delayed.

4.2. Gender Differences of Predictive Bias

Independent sample t-test found that in low anxiety group no significant gender differences existed in three kinds of stimulus situations. However, in high anxiety group, no significant gender differences existed in 100% predictable situation, while statistically significant gender differences could be found in 50% predictable and unpredictable situations. Consistent with the results of Lejuez *et al*. [6] and Grillon [3], females showed more significant panic reflex than males to the clues in unpredictable situations.

Studies have confirmed that one of the reasons why females suffered from anxiety disorder more than males was that sex hormones influenced the course of panic regression [23, 24]. Individuals all show more significant panic reflex to the clues in unpredictable situation. Compared with males, however, it is more difficult for females to avoid this kind of panic reflex because high female progesterone in them makes panic regression more difficult.

Grillon [3] explained in his article that this may be due to the experimental design itself which was easier to identify the gender differences of aversive motivation. Aversive stimulus used in Grillon's study was more likely to lead to individuals' physical arousal, including heart rate (HR), nonspecific skin conductance response (NS-SCR), etc.

In this experiment, unpredictability in 50% predictable and unpredictable situations made it difficult for individuals to adjust anxiety, which may lead to a constant state of anxiety. Compared with males of high trait anxiety, it is more difficult for females of high trait anxiety to deal with the persistent anxiety. Therefore, high trait anxious women showed more significantly delayed response in 50% predictable and unpredictable stimulus situations.

The reason why unpredictable stimulus is likely to lead to individuals' anxiety, even persistent anxiety, is that the nature of unpredictability is nervousness. Predictable stimulus may produce less nervousness because the presence of clues can provide a period of relatively reduced nervousness. Therefore, predictability is a fundamental regulator of anxiety. Non-clinical individuals would rather choose the happening of predictable events. This explanation, to some degree, is identical to the safety-signal hypothesis [12].

Surely, this study is just a preliminary exploration on the predictive bias of non-clinical individuals to neutral stimuli and on the relationship between trait anxiety, gender and stimulus situations, and the research itself also has some shortcomings. On the one hand, the study just focuses on the behavioral responses of non-clinical anxious individual, without taking physiological mechanism into consideration; on the other hand, only one target stimulus is involved in stimulus situations, which may result in participants' mechanical responses and affect the scientific nature of the result of the experiment. The neural mechanism of predictive bias to neutral stimuli of non-clinical anxious individuals is still not clear, which needs to be further explored on the physical level.

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