Gender Difference of Unconscious Attentional Bias in High Trait Anxiety Individuals

Jieqing Tan[1], Zheng Ma[1,3], Xiaochao Gao[1], anhong Wu[1,2]*, Fang Fang[1]

1 Department of Psychology, Peking University, Beijing, China, **2** Learning and Cognition Lab, Capital Normal University, Beijing, China, **3** Yuanpei College, Peking University, Beijing, China

Abstract

By combining binocular suppression technique and a probe detection paradigm, we investigated attentional bias to invisible stimuli and its gender difference in both high trait anxiety (HTA) and low trait anxiety (LTA) individuals. As an attentional cue, happy or fearful face pictures were presented to HTAs and LTAs for 800 ms either consciously or unconsciously (through binocular suppression). Participants were asked to judge the orientation of a gabor patch following the face pictures. Their performance was used to measure attentional effect induced by the cue. We found gender differences of attentional effect only in the unconscious condition with HTAs. Female HTAs exhibited difficulty in disengaging attention from the location where fearful faces were presented, while male HTAs showed attentional avoidance of it. Our results suggested that the failure to find attentional avoidance of threatening stimuli in many previous studies might be attributed to consciously presented stimuli and data analysis regardless of participants' gender. These findings also contributed to our understanding of gender difference in anxiety disorder.

Citation: Tan J, Ma Z, Gao X, Wu Y, Fang F (2011) Gender Difference of Unconscious Attentional Bias in High Trait Anxiety Individuals. PLoS ONE 6(5): e20305. doi:10.1371/journal.pone.0020305

Editor: James G. Scott, The University of Queensland, Australia

Received December 16, 2010; **Accepted** April 29, 2011; **Published** May 24, 2011

Funding: Work was funded by Natural Science Foundation of China http://www.nsfc.gov.cn/ (31070982, 30770711, 30470568); Major State Basic Research Development Program of China (973) www.most.gov.cn/ (2009CB320901). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing Interests: The authors have declared that no competing interests exist.

* E-mail: wuyh@pku.edu.cn

Introduction

Generalized anxiety disorder (GAD) is an anxiety disorder that is characterized by excessive, uncontrollable and often irrational worry about everyday things, which is disproportionate to the actual source of worry [1]. To study its psychopathology, researchers usually adopted patients with generalized anxiety disorder as clinical sample and individuals with high trait anxiety as subclinical sample

presented to the two eyes that cannot be merged to a single visual percept, binocular rivalry occurs. Observer's perception switches back and forth between the two incompatible pictures, that is, they compete for perceptual dominance [17]. Some factors could boost the strength of one rival picture over another, such as high-contrast, brighter stimulus, moving contours, densely contoured, and stimuli presented in dominant eye [18]. Accordingly, the 'stronger' competitor enjoys an advantage in overall perceptual dominance. Jiang et al. [19] took advantage of binocular rivalry to study the effect of invisible images on the distribution of spatial attention. In their study, high contrast dynamic noise was presented to the dominant eye, and a meaningful picture was presented to the non-dominant eye. Because of the strong inter-ocular suppression by the dynamic noise, subjects were completely unaware of the meaningful picture. They found that a 800 ms presentation of invisible pictures could result in attentional bias and the bias was dependent on subjects' gender. This experimental paradigm is also call binocular suppression because of the imbalance of the strength of the two competing stimuli. In our study, we will use binocular suppression to render images invisible for a long presentation and investigate attentional bias at unconscious level.

We suspect that the failure to find attentional avoidance of threatening stimuli in many previous studies might be, at least partially, attributed to data analysis regardless of participants' gender. Many researches have indicated that there are gender differences in attention to and appraising of threat, which means females are more sensitive to threat-related cues than males and tend to overestimate the level of danger [20,21]. McClure et al.

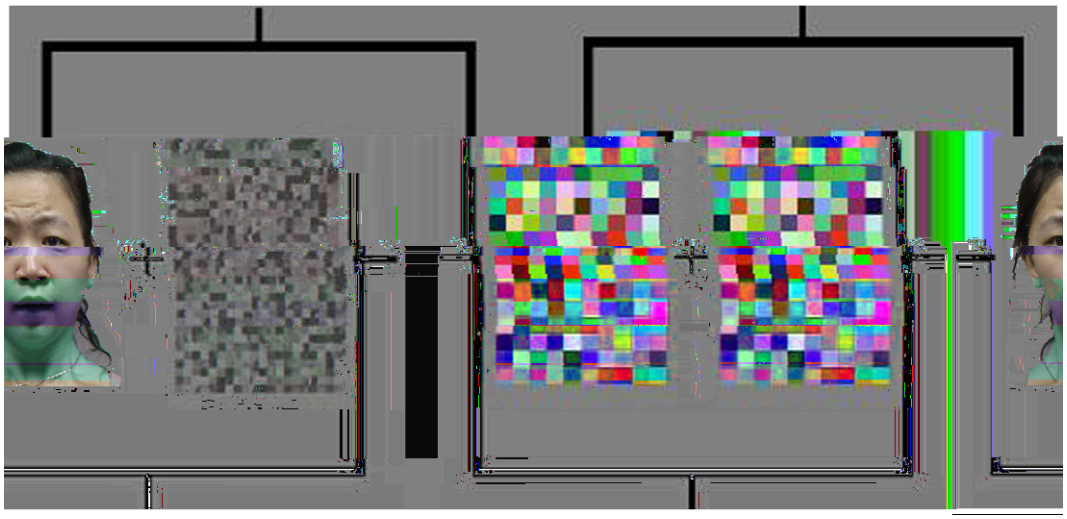

Figure 1. A sample stimulus in the invisible condition. The left image was presented to the non-dominant eye and the right image was presented to the dominant eye.
doi:10.1371/journal.pone.0020305.g001

participants were required to press one of two buttons to indicate their perceived orientation of the gabor patch regardless of the side of presentation (see Figure 2).

Total 256 trials were randomized across experimental conditions, including position of face image (left or right to the fixation point), position of the gabor probe (left or right to the fixation point), face emotion (fearful or happy), face gender (male or female) and visibility (visible or invisible). These trials were divided into four blocks, 64 trials for each block.

Before the experiment, participants practiced 50 trials for the invisible condition to get familiar with the experimental procedure. Those who reported seeing face images in the invisible condition were excluded from the experiment.

Design. For the independent variables, the between-subject variables were group (high trait anxiety vs. low trait anxiety) and gender (female vs. male). The within-subject variables were emotion (fearful vs. happy) and visibility (visible vs. invisible). The dependent variable was the orientation discrimination accuracy of the gabor patch. The working hypothesis was that if there were attentional effects (either bias or avoidance) induced by the emotional pictures as a cue, the discrimination accuracy would be increased or decreased. We quantified attentional effect as the discrimination accuracy of the gabor probe presented at the position of the intact image minus the discrimination accuracy of the gabor probe presented at the position of the scrambled image, following the method in Jiang et al. (2006) [19].

A positive value of attentional effect indicated attentional bias, which meant that attention was oriented toward emotional images, and a negative value indicated attentional avoidance, which meant that attention was oriented away from emotional images. Attentional effects were analyzed separately for the visible condition and the invisible condition, and the later one was one of the focuses of this study.

Results

Visible condition. Attentional effects by happy and fearful faces in HTA and LTA groups are presented in Figure 3. A 2×2×2 mixed-design ANOVA, with face emotion (happy/fearful) as within-subject variable, and anxiety state (HTA/LTA) and gender (female/male) as between-subject variables, revealed only a marginal effect for state × gender ($F(1, 44) = 3.75$, $p = 0.059$), no other significant main effect and interaction.

Invisible condition. Attentional effects by happy and fearful faces in HTA and LTA groups are presented in Figure 4.

A similar 2 (face emotion)×2 (anxiety state)×2 (gender) mixed-design ANOVA showed a significant interaction between emotion and gender ($F(1, 44) = 6.59$, $p = 0.014$), which indicated a gender difference of attentional effect induced by emotional pictures. The interaction between gender and anxiety state was significant ($F(1, 44) = 4.77$, $p = 0.034$), suggesting that the gender difference of

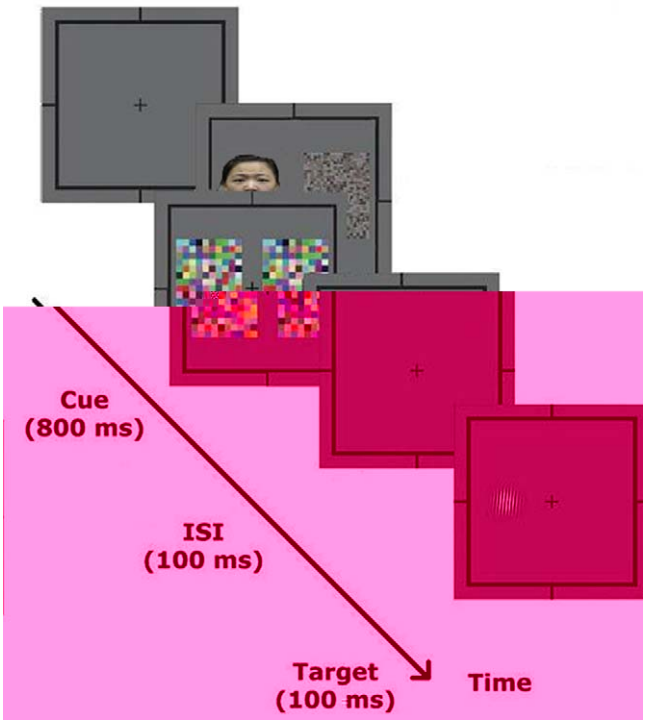

Figure 2. A schematic description of the experimental procedure in the invisible condition.
doi:10.1371/journal.pone.0020305.g002

attentional effect was dependent on anxiety state. Thus, we performed 2 (face emotion)×2 (gender) ANOVA s for the HTA and LTA groups separately. The interaction between face emotion and gender reached a significant level in the HTA group ($F(1, 22) = 5.35$, $p = 0.031$), but not in the LTA group ($F(1, 22) = 1.89$, $p = 0.183$). In addition, the HTA group also exhibited a marginally significant gender effect ($F(1, 22) = 4.11$, $p = 0.055$). A one sample t-test was conducted to further confirm the effect of interaction, and revealed that female participants in the HTA group showed a significant attentional bias towards fearful faces ($t(11) = 2.66$, $p = 0.022$). It is also worth noting that mpale .9(male)-450.369.5(the-168d(racti0e4ot)-4.9(the)-277.4(HTA)-)-277(group)-283.5(sh-28-17249.3(a)-246-288

Table 2. STAI-TAI scores of female and male participants in HTA group and T-Test between two genders.

	Female	Male	t	P
HTA	52.83(9.77)	52.83(6.64)	0.00	1.00

doi:10.1371/journal.pone.0020305.t002

Design. A between-subject independent variable was gender (female vs. male). Within-subject independent variables were emotion (fearful vs. neutral vs. happy) and visibility (visible vs. invisible). Data were analyzed separately for the visible condition and invisible condition.

Results

Attentional effects by neutral, happy and fearful faces in the HTA group were presented in Figure 5. A 2 (female/male)×3 (happy/neutral/fearful) mixed-design ANOVA was performed for the visible condition and invisible condition separately.

No significant effects were found in the visible condition. In the invisible condition, the interaction of gender and emotion was significant ($F(2, 33) = 5.6$, $p = 0.008$), and the main effect of gender was also significant ($F(1, 34) = 8.62$, $p = 0.006$). A one sample t-test found that, female participants exhibited attentional bias to fearful faces ($t(17) = 2.89$, $p = 0.01$), while male participants exhibited attentional avoidance of fearful faces ($t(17) = -3.75$, $p = 0.002$). This result supported that there was gender difference in HTA population. Additionally, we did not find attentional effects by both neutral and happy faces (see Figure 5).

Discussion

Using binocular suppression to render face images invisible, we found that invisible fearful faces could alter the distribution of spatial attention in HTA individuals. The attentional effect was gender-dependent. Specifically, HTA males showed attentional avoidance of invisible fearful faces, but HTA females showed attentional bias towards them. No significant attentional effect was found in the visible condition, in LTA individuals, and with neutral and happy face images.

Consistent with previous studies [5,12,35], we did not find attentional avoidance of fearful faces in the HTA group in the visible condition. Such a reliable observation across 800 ms, 1250 ms and 1500 ms presentation duration demonstrates that the null effect is not likely to be an artifact and this observation cannot be fully explained by the "vigilance-avoidance" model proposed by Mogg and Bradley (1998). On the other hand, the attenitonal effect in the invisible condition and its gender difference support our hypotheses and make us to re-think about cognitive processes at unconscious level.

In the invisible condition, HTA male participants exhibited attention avoidance of fearful faces, which can be considered to have some positive values. Recent models about attention to threat [7,8,36] have emphasized the adaptive value of strategic attentional avoidance in some situations. For example, when some stimuli need not to be processed immediately, attention avoidance could be a good strategy to complete current tasks [8], or regulate mood by avoid processing negative information [37]. HTA female participants exhibited attention bias to fearful faces. The bias may not indicate attention shift to the threatening images because of their long presentation. Instead, it might reflect female participants' difficulty to disengage their attention from threatening stimuli. Since the shift of spatial attention could be operated at a fine temporal scale (e.g. 200–300 ms, see [38]), the 800 ms presentation time in our study is sufficient for participants to move attention towards and away from non-prefered stimuli. The disengage difficulty in HTA female participants may reflect their excessive processing in threatened materials [39]. This result is consistent with a previous study that women may tend to overestimate the potential of threat, and are more anxiety sensitive than men [40]. This might have some implications for clinical practice. MacLeod and Hagan [41] had females who were waiting for gynecology procedure to do a masked Stroop task and told some of them that they have been diagnosed cervicitis. They showed that attentional bias induced by subliminal stimuli could predict the following emotional collapse. Thus, subliminal attentional bias could reflect one's vulnerability to stress. The

Figure 5. Attention bias and avoidance by neutral, happy and fearful faces in the invisible condition. Female participants exhibited attentional bias to fearful faces, while male participants exhibited attentional avoidance of fearful faces. This result supported that there was gender difference in HTA population. Additionally, we did not find attentional effects by both neutral and happy faces. Error bars denote 1 SEM calculated across subjects.
doi:10.1371/journal.pone.0020305.g005

HTA females in our study may be vulnerable to fearful faces, so that they could not direct their attention away from the negative information.

Our study emphasizes two important issues in psychopathological researches. One is consciousness manipulation, the other is gender difference. Previous studies [8,42,43] have tried different presentation durations to manipulate consciousness, some of which were combined with backward masking. Cognitive information processing at conscious level typically involves both bottom-up and top-down processes. On the other hand, unconscious processing is usually considered to a bottom-up process, which might reflect an instinctive process without top-down cognitive controls [44]. Measuring emotional processing at conscious level usually suffers the cognitive inferences (e.g. strategies) from top-down processes, which might prevent a direct measure of the instinctive process. Using invisible stimuli is a feasible way to overcome this difficulty. The finding of attentional effect only in the invisible condition supports our view. What' more, from the psychodynamic perspective, our result may also reflect the different unconscious effect of previous psychological experiences on HTA and LTA individuals. It should also be noted that binocular suppression has many advantages for studying unconscious emotional processing (e.g. the long and complete suppression of stimuli out of awareness, see the review by Kim and Blake [45]). The technique has been used to accurately predict sexual orientation [19]. It is worthwhile to apply this technique to other emotional researches.

We demonstrated the existence of gender difference in anxiety population and suggested the importance of balancing participants' gender in future studies. Previous studies used anxious participants with different ratios of genders, which generated distinctive conclusions. Our study adopted equal numbers of female and male participants and found significant, but different, attentional effects for each gender. Future studies should consider gender difference as an important factor in anxiety research.

In conclusion, we found attentional effects induced by fearful faces at unconscious level, and the effects were distinct for male and female participants. These findings may contribute to our understanding of gender difference in anxiety disorder.

Author Contributions

Conceived and designed the experiments: YW JT FF. Performed the experiments: JT ZM XG. Analyzed the data: JT ZM. Contributed reagents/materials/analysis tools: JT ZM. Wrote the paper: YW JT ZM FF.

References

1. American Psychiatric Association (1994) The fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV). Washington: American Psychiatric Association. 204 p.
2. Gibbs NA (1996) Non-clinical populations in research on obsessive-compulsive disorder: A critical review. Clin Psycho Rev 16: 729–773.
3. Beck AT, Emery G, Greenberg RL (1985) Anxiety disorders and phobias: a cognitive perspective. New York: Basic Books.
4. Williams JMG, Watts FN, MacLeod CM, Mathews A (1988) Cognitive psychology and the emotional disorders. Chichester: Wiley.
5. Bradley BP, Mogg K, Falla JS, Hailton LR (1998) Attentional bias for threatening facial expressions in anxiety: manipulation of stimulus duration. Cognition Emotion 12: 737–753.
6. Mogg K, Bradley BP (1999) Orienting of attention to threatening facial expressions presented under conditions of restricted awareness. Cognition Emotion 13: 713–740.
7. Koster EHW, Verschuere B, Crombez G, Damme SV (2005) Time-course of attention for threatening pictures in high and low trait anxiety. Behav Res Thera 43: 1087–1098.
8. Mogg K, Bradley BP (1998) A cognitive-motivational analysis of anxiety. Behav Res Ther 36: 809–848.
9. Rachman S (1998) Anxiety. Hove: Psychology Press.
10. MacLeod C, Mathews A, Tata P (1986) Attentional bias in emotional disorders. J Abnorm Psychol 95: 15–20.
11. Broadbent D, Broadbent M (1988) Anxiety and attentional bias: State and trait. Cognition Emotion 2: 165–183.
12. Mogg K, Bradley BP, Miles F, Dixon R (2004) Time course of attentional bias for threat scenes: testing the vigilance-avoidance hypothesis. Cognition Emotion 18: 689–700.
13. Mayer B, Merckelbach H (1999) Unconscious processes, Subliminal stimulation, and anxiety. Clin Psychol Rev 19: 571–590.
14. Mogg K, Bradley BP, William R, Mathews A (1993) Subliminal processing of emotional information in anxiety and depression. J Abnorm Psychol 102: 304–311.
15. Mogg K, Bradley BP, Millar N, White J (1995) A follow-up study of cognitive bias in generalized anxiety disorder. Behav Res and Ther 33: 927–935.
16. Yovel I, Mineka S (2005) Emotion-congruent attentional biases: the perspective of hierarchical models of emotional disorders. Pers Indiv Diffe 38: 785–795.
17. Blake R, Logothetis NK (2002) Visual competition. Nat Rev Neurosci 3: 13–21.
18. Fang F, He S (2005) Cortical responses to invisible objects in human dorsal and ventral pathways. Nat Neurosci 8: 1380–1385.
19. Jiang Y, Costello P, Fang F, Huang M, He S (2006) A gender- and sexual orientation-dependent spatial attentional effect of invisible images. PNAS 103: 17048–17052.
20. Goos LM, Silverman I (2002) Sex related factors in the perception of threatening facial expressions. J Nonverbal Behav 26: 27–41.
21. McClure EB (2000) A meta-analytic review of sex differences in facial expression processing and their development in infants, children, and adolescents. Psychol Bull 126: 424–453.
22. McClure EB, Monk CS, Nelson EE, Zarahn E, Leibenluft E, et al. (2004) A developmental examination of gender differences in brain engagement during evaluation of threat. Biol Psychiat 55: 1047–1055.
23. Bekker MHJ (1996) Agoraphobia and gender: A review. Clin Psycho Rev 16: 129–146.
24. Fredrikson M, Annas P, Fischer H, Wik G (1996) Gender and age differences in the prevalence of specific fears and phobias. Behav Res and Ther 34: 33–39.
25. Castle DJ, Deale A, Marks IM (1995) Gender differences in obsessive compulsive disorder. Aust Nz J Psychiat 29: 114–117.
26. Breslau N, Schultz L, Peterson E (1995) Sex differences in depression: a role for preexisting anxiety. Psychiat Res 58: 1–12.
27. Simonds VM, Whiffen VE (2003) Are gender differences in depression explained by gender differences in co-morbid anxiety? J Affective Disorders 77: 197–202.
28. Waters AM, Valvoi JS (2009) Attentional bias for emotional faces in paediatric anxiety disorders: An investigation using the emotional go/no go task. J Behav Ther Exp Psy 40: 206–316.
29. Osorio LC, Cohen M, Escobar SE, Salkowski-Bartlett A, Compton RJ (2003) Selective attention to stressful distracters: effects of neuroticism and gender. Pers Indiv Differ 34: 831–844.
30. Jansson B, Lundh L, Oldenburg C (2005) Is defensiveness associated with cognitive bias away from emotional information? Pers Indiv Differ 39: 1373–1382.
31. Rossignol M, Philippot P, Douilliez C, Crommelinck M, Campanella S (2005) The perception of fearful and happy facial expression is modulated by anxiety: an event-related potential study. Neuroscience 377: 115–120.
32. Spielberger CD, Gorsuch RL, Lushene R, Vagg PR, Jacobs GA (1983) Manual for the state–trait anxiety inventory. Palo Alto, CA: Consulting Psychologists Press.
33. Zhen X (1993) Status-trait inventory tested in Changchun (in Chinese). Chinese J Clin Psychol 17: 60–62.
34. Bai L, Ma H, Huang YX, Luo YJ (2005) The Development of Native Chinese Affective Picture System-A pretest in 46 College Students. Chinese Ment Health J 19: 719–722.
35. Mogg K, Bradley BP, de Bono J, Painter M (1997) Time course of attentional bias for threat information in non-clinical anxiety. Behav Res and Ther 35: 297–303.
36. Eccleston C, Crombez G (1999) Pain demands attention: a cognitive-affective model of the interruptive function of pain. Psycho Bull 125: 356–366.
37. Ellenbogen MA, Schwartzman AE, Stewart J, Walker CD (2002) Stress and selective attention: The interplay of mood, cortisol levels, and emotional information processing. Psychophysiology 39: 723–732.
38. Kowler E (1995) Eye movements. In: Kosslyn SM, Osheron DN, eds. Visual cognition. Cambridge, MA: MIT Press. pp 215–265.
39. Koster EHW, Crombez G, Verschuere B, De Houwer J (2004) Selective attention to threat in the dot probe paradigm: differentiating vigilance and difficulty to disengage. Behav Res Thera 42: 1183–1192.
40. McLean CP, Anderson ER (2009) Brave men and timid women? A review of the gender differences in fear and anxiety. Clin Psycho Rev 29: 496–505.

41. MacLeod C, Hagan R (1992) Individual differences in the selective processing of threatening information, and emotional responses to a stressful life event. Behav Res Thera 30: 151–161.
42. Mathews A, MacLeod C (1994) Cognitive approaches to emotion and emotional disorders. Annu Rev Psychol 45: 25–40.
43. Williams JMG, Watts FN, MacLeod C, Mathews A (1997) Cognitive psychology and emotional disorders (2nd ed.). Chichester, UK: Wiley.
44. Koch C, Tsuchiya N (2006) Attention and consciousness: two distinct brain processes. Trends Cogn Sci 11: 16–22.
45. Kim C, Blake R (2005) Psychophysical magic: rendering the visible 'invisible'. Trends Cogn Sci 9: 381–388.