



SciVerse ScienceDirect

Procedia - Social and Behavioral Sciences 32 (2012) 40 – 44

Procedia
Social and Behavioral Sciences

4th International Conference of Cognitive Science (ICCS 2011)

A comparative study of working memory executive functions processing efficiency considering high and low levels of anxiety

Pegah Darvishzadeh^a, Maria E. Aguilar-Vafaie^{a,*}, Ali R. Moradi^a^a*Department of Psychology, Tarbiat Modares University, Tehran, Iran*

Abstract

The present research has been designed based on Attentional Control Theory (ACT). Anxiety leads to increased use of resources, and affects performance efficiency more than effectiveness. Participants consisted of a convenience sample of females with high and low levels of trait/state anxiety. A one-way analysis of variance yielded significant results for group, type of words and group*type of word interaction. These findings indicate a disruption in inhibitory and switching processing efficiency in the high anxiety group, and are in agreement with top-down processing biases of attention theory.

© 2011 Published by Elsevier Ltd. Selection and/or peer-review under responsibility of the 4th International Conference of Cognitive Science. Open access under [CC BY-NC-ND license](http://creativecommons.org/licenses/by-nc-nd/3.0/).

Keywords: Anxiety; working memory; central executive; processing efficiency; Emotional Word Stroop Task; Wisconsin Sorting Card Test

1. Introduction

The present research has been designed based on the latest revised version of the processing efficiency theory (Eysenck & Calvo, 1992), the Attentional Control Theory (ACT; Eysenck, Derakshan, Santos, & Calvo, 2007), which uses Baddeley's (2007) working memory model comprising a central executive and two sub-systems and in which the central executive is modality-free and controls incoming information. Accordingly, anxiety utilizes resources of the central executive (Lavie, Hirst, de Fockert, & Viding, 2004) leading to fewer processing resources being available for task demands, in both adults (Anderson, 2005; Derakshan & Eysenck, 1998; Eysenck & Byrne, 1992) and children (Hadwin, Borgan, & Stevenson, 2005) and this effect is specific (Eysenck, Payne, & Derakshan, 2005; Fox, 1993), affecting performance (Murray & Janelle, 2003). High-anxious individuals employ strategies (i.e., increased effort) to reduce the adverse effects of anxiety (e.g., Ikeda, Iwanage, & Seiwa, 1996; Lemaire, Abdi, & Fayol, 1996). According to the ACT theory, the distinction between performance effectiveness (performance quality) and processing efficiency (relationship between effectiveness and use of resources) is of central importance – theoretically, anxiety leads to increased use of resources, and affects performance efficiency more than effectiveness (Eysenck & Calvo, 1992). However, the functions of the central executive impaired by anxiety are unclear (Dresler, Meriau, Heekeren, & Van der Meer, 2009; Egloff & Hock, 2001; Schultz & Heimberg, 2008).

* Corresponding author. Tel.: +98-21-82883314; Fax: +98-21-82883314
E-mail address: Vafaiesm@modares.ac.ir

Based on Posner and Peterson (1990) early work and Corbetta and Shulman's (2002) more recent research, ACT postulates that anxiety alters the balance between the stimulus-driven attentional system and the top-down, goal-driven attentional system, reducing the influence of the latter system. Empirical evidence also indicates that threat cues lead to selective processing in high anxious individuals (e.g., Martin, Williams, & Clark, 1991; Mogg & Marden, 1990) and this processing is automatic (Mathews & MacLeod, 1986; McNally, Amir, & Lipke, 1996).

Based on the above theoretical postulations and empirical evidence, it was hypothesized that high-anxiety participants in comparison with their low-anxiety counterparts will demonstrate less ability in inhibiting preponderant responses in the Emotional Stroop Test (ETS) and in changing mental-set ability, as measured by the Wisconsin Sorting Card Test (WSCT). In addition, self-perceptions of cognitive effort will significantly differ in low- and high-groups.

2. Method

2.1. Participants

These were 40 female graduate students (mean age of 27 years) from Tarbiat Modares University, Tehran, Islamic Republic of Iran. All participants had Farsi as their primary language. They participated voluntarily and did not receive course or any other credit for participating in the study. They were selected from a larger sample of 300 volunteers who completed screening measures of the trait version of the State Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) several weeks prior to the study.

2.2. Measures

2.2.2. Emotional Word Stroop Task

A modified Stroop Color-naming Task similar to that of MacLeod (1991), Mathews and McLeod (1985) and Williams, Mathews, & MacLeod (1996) was utilized. Participants were asked to name the ink color of words which were presented on a Computer screen over a black background. GAD-related threatening words, positive words, and neutral words were presented in blocks. The word stimuli consisted of 16 threat-related, 16 positive, and 16 neutral (household-related) words, which were previously used by Neshat-Doost, Taghavi, Moradi, Yule, & Dalgleish, (1997) and which were evaluated by graduate students specifically for this study in terms of the degree of negative, positive and neutral valences, and by a psycholinguist in terms of word frequency and morphology. Based on this analysis, the words with highest ratings in each category were chosen. Each word was presented in colored (red, green, blue, or yellow) Farsi letters. An additional 10 words were used on practice and buffer trials. Each word was approximately 3-10 cm (height -width). Lists of words are available from the authors upon request.

2.2.1. Wisconsin Sorting Card Test (WSCT)

The Wisconsin Card Sorting Test (WCST) is a commonly used neuropsychological test that has shown some specific sensitivity to frontal lobe lesions (Heaton, 1981). The standard WCST consists of 128 cards, each of which contains geometric figures that may vary along three dimensions (color, form, number). Participants are instructed to place each card below one of four target or key cards using some principle to guide them. They are not informed of the correct principle but are told whether they are correct or incorrect after their placement of each card. The initial sorting principle is to match according to color. Once a criterion of 10 correctly sorted cards is attained, the principle is changed, although the participant is not informed of this change. The test proceeds until the participant has completed six sorting categories, each consisting of 10 consecutive cards matching the sorting principle in force, or has sorted all 128 cards, whichever occurs first. The types of errors that are elicited may vary, although the most sensitive response type with respect to frontal lobe dysfunction is the perseverative response, reflecting subjects' difficulty in shifting their strategies or cognitive sets.

2.2.3. Procedure

Participants first gave written consent and were assessed individually in the university's psychology laboratory. Then, participants completed the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) immediately after consent procedures. Participants were categorized into low- and high-anxiety groups based on sample norms (1 standard deviation scores above the mean, high anxiety $n = 20$, and low anxiety $n = 20$).

Average trait anxiety scores were $M = 61.55$, $SD = 6.30$, range 53-76 in the high anxiety group and $M = 25.25$, $SD = 2.55$, range 21-29 in the low anxiety group. Low- and high-trait anxiety groups did not differ on any demographic variables.

In the next step, the Emotional Word Stroop Test was administered in a computerized format, participants were seated 110 cm from a computer screen for. The Emotional Word Stroop Test had 20 practice trials, 2 buffer trials, and 192 experimental trials, which consisted of an equal number (64) of trials with threat, positive, and neutral words. There were an equal number of trials in each color condition for each word type. Trials were presented in a new random order for each participant. Each trial started with a centrally located fixation cross, followed by the colored word, which remained on the screen until a manual response was recorded (maximum 2000 ms). Participants were asked to say aloud the color of the word as quickly as possible without making mistakes, a response was recorded by the participant by pressing a button in the computer key board. Each emotional Stroop task took approximately 10 min.

The manual version of the WSCT was administered according to standard instructions from the manual (Heaton, 1981). In the present study, a master degree student in psychology who had previously been trained in the WSCT, administered the test for all participants. This task took approximately 10 min. After completion of each task, participants responded to a self-report measure of mental effort.

3. Results

Emotional Word Stroop Task RTs from trials with errors (2%) and RT outliers (< 250 ms and > 3 SDs above each participant's mean; 1% of trials) were excluded. Interference scores were calculated separately for each emotional word type and participant by subtracting the mean RT for neutral words from the mean RT for each category of emotional word. This produced separate interference scores for threat, positive and neutral words. In order to answer to the first hypothesis of the study, first, we examined the performance of two groups of participants (high and low anxiety) considering the three categories of words (threatening, positive, and neutral) through a 2 (high and low anxiety) \times 3 (threatening, positive, and neutral) repeated measures *ANOVA*, where there is two levels of the *between-subjects* factor (group) and three levels of the *within-subjects* factor (type of word).

The use of this analysis allows us to answer to three fundamental research questions. First, we would like to know whether there is a significant difference between the two groups of participants. The second question address the main effect of the repeated measures, that is, did the participants perform equally in terms of reaction times to the three types of word stimuli (threatening, positive, and neutral)? Finally, the third question deals with possible interaction effects between the two factors (group and types of words); that is, is the trend of reaction time patterns across threatening, positive and neutral words similar for high and low anxiety groups?

Results from a 2 (high-low anxiety) \times 3 (type of words) one-way analysis of variance controlling for depression yielded significant results for group $F(39) = 15.69$, $p < 0.0001$; thus, results from this analysis with respect to the first question, indicate that there is a highly significant difference in the EST performance between the two groups of participants, as the results between-subjects indicate. Secondly, the participants did not performed equally in terms of reaction times to respond to the three types of word stimuli (threatening, positive and neutral), as indicated by the significant type of words main effect obtained, $F(2) = 5.15$, $p < 0.03$). Specifically, participants took significantly longer times to respond to threatening words in comparison to positive words and neutral words, but no significant differences were obtained in reaction times for positive words in comparison to neutral words. Lastly, results related to the third question revealed a significant interaction effect between the two factors interaction effect between group \times type of word, $F(6) = 4.36$, $p < 0.04$; that is, the trend of reaction time patterns across threatening, positive and neutral words was significantly different for high and low anxiety groups.

In order to address the second hypothesis of this study, an independent sample t-test yielded significant results for perseveration error responses $t(30) = 6.24$, $p < 0.001$ on the WSCT as well as higher scores on most other WSCT indices (i.e., number of completed sets $t(38) = -5.61$, $p < 0.001$, number of errors $t(38) = 7.19$, $p < 0.001$, number of attempted solutions $t(38) = 7.60$, $p < 0.001$, perceptual level responses $t(38) = -3.29$, $p < 0.001$) that denoted impaired performance of executive function of the high anxiety group.

Finally, high-anxious participants significantly reported higher mental effort than low-anxious participants in both tasks, the EST, $t(38) = 1.75$, $p < 0.001$ and WISC, $t(38) = 3.42$, $p < 0.002$.

4. Discussion

These findings indicate a disruption in inhibitory and switching processing efficiency in the high anxiety group, and are in agreement with Monsell's (2000) and Goodwin & Sher (1992) findings regarding switching ability and anxiety, specifically about ACT efficiency predictions Santos and Eysenck, 2006 and Hasher, Lusting, and Zacks (2007) findings about the role of inhibitory mechanisms in the control of attention. The present research provides evidence for the linear relationship between anxiety and attentional bias, resulting in higher interference in inhibitory and switching executive functions. These findings are in agreement with meta-analytic studies on threat related attentional biases in anxiety (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007) which indicates that the bias is of comparable magnitude across different types of anxious populations (individuals with different clinical disorders, high-anxious nonclinical individuals, anxious children and adults) and is not observed in nonanxious individuals. Also, the obtained evidence of a bias in processing of negative and positive words between the two groups as depicted by the group x reaction time interaction effect is contrary to attention control theory predictions but is in line with Dresler and colleagues (Dresler et al., 2009) findings.

Among the limitations of the present study we can refer to the lack of control of level arousal. Although the majority of research indicates that the interference effect may reflect increased allocation of attentional resources to emotional stimuli, especially negative ones, there is new evidence indicating that allocation of attentional resources is rather mediated by arousal of stimuli (high arousal meaning words that induce highest levels of emotional reaction, regardless of their negative or positive valence). Thus, not matching for level of arousal of positive and negative words is one important limitation of the present study.

It is recommended that in future research a different emotional Stroop task be designed using a more naturalistic class of stimuli be administered to different groups of participants to make results more generalizable. Also, the trait-state anxiety distinction needs to be directly manipulated, to determine the causal paths between the two. Third, due to the highly consistent findings concerning trait anxiety as a factor enhancing emotional interference in non-clinical anxious participants, the present research focused on trait anxiety. However, only few studies have examined the influence of state anxiety or interactive effects of trait and state anxiety on emotional interference and have produced inconsistent results. Therefore, it is recommended that in future investigations the independent influence of state and trait anxiety on emotional interference be investigated separately. Fourth, it is suggested that researchers invest greater efforts in establishing the causal developmental link between childhood and adult anxiety. Finally, more research is needed in the use of threat-related bias in anxious and non-anxious children, in particular using exposure of emotional words at the unconscious (subliminal) level.

References

- Anderson, A. K. (2005). Affective influences on the attentional dynamics supporting awareness. *Journal of Experimental Psychology: General*, 134, 258-281.
- Baddeley, A. (2007). Fractionating the central executive. In A. Baddeley (Ed.), *Working memory, thought, and action* (pp. 117-138). New York: Oxford University Press.
- Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van IJzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin*, 133, 1-24.
- Beck, A. T., Ward, C. H., Mendelson, M., Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. *Archives of General Psychiatry*, 4, 561-569.
- Corbetta, M., & Shulman, G. L. (2002). Control of goal-directed and stimulus-driven attention in the brain. *Nature Reviews Neuroscience*, 3, 201-215.
- Derakshan, N., & Eysenck, M. W. (1998). Working memory capacity in high trait-anxious and repressor groups. *Cognition and Emotion*, 12, 697-713.
- Dresler, T., Meriau, K., Heekeren, H. R., & Van der Meer, E. (2009). Emotional Stroop Task: Effect of word arousal and subject anxiety on emotional interference. *Psychological Research*, 73, 364-371.
- Egloff, B., & Hock, M. (2001). Interactive effects of state anxiety and trait anxiety on emotional Stroop interference. *Personality and Individual Differences*, 31, 875-882.
- Eysenck, M. W., & Byrne, A. (1992). Anxiety and susceptibility to distraction. *Personality and Individual Differences*, 13, 793-798.
- Eysenck, M. W., Derakshan, N., Santos R., & Calvo M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion*, 7, 336-353.
- Eysenck, M. W., Payne, S., & Derakshan, N. (2005). Trait anxiety, visuo-spatial processing and working memory. *Cognition and Emotion*, 19, 1214-1228.
- Eysenck, M. W., & Calvo, M. G. (1992). Anxiety and performance: The processing efficiency theory. *Cognition and Emotion*, 6, 409-434.
- Fox, E. (1993). Attentional bias in anxiety: Selective or not? *Behavior Research and Therapy*, 31, 487-493.

- Goodwin, A. H., & Sher, K. J. (1992). Deficits in set-shifting ability in nonclinical compulsive checkers. *Journal of Psychopathology and Behavioral*, 14, 81-92.
- Hadwin, J., Borgan, J., & Stevenson, J. (2005). State anxiety and working memory in children: A test of processing efficiency theory. *Educational Psychology*, 25, 379-393.
- Hasher, L., Lusting, C., & Zacks, R. (2007). Inhibitory mechanisms and the control of attention. In A. Conway, C. Jarrold, M. Kane, A. Miyake, & J. Towse (Eds.), *Variation in working memory* (pp. 227-249). New York: Oxford University Press.
- Heaton, R. K. (1981). *Wisconsin Card Sorting Test manual*. Odesa, Fla: Psychological Assessment.
- Ikeda, M., Iwanaga, M., & Seiwa, H. (1996). Test anxiety and working memory system. *Perceptual and Motor Skills*, 82, 1223-1231.
- Lavie, N., Hirst, A., de Fockert, J. W., & Viding, E. (2004). Load theory of selective attention and cognitive control. *Journal of Experimental Psychology: General*, 133, 339-354.
- Lemaire, P., Abdi, H., & Fayol, M. (1996). The role of working memory resources in simple cognitive arithmetic. *European Journal of Cognitive Psychology*, 8, 73-103.
- MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin*, 109, 163–203.
- Martin, M., Williams, R. M., & Clark, D. M. (1991). Does anxiety lead to selective processing of threat-related information? *Behavior Research and Therapy*, 29, 147-160.
- Mathews, A., & MacLeod, C. (1985). Selective processing of threat cues in anxiety states. *Behavior Research and Therapy*, 23, 563-569.
- Mathews, A., & MacLeod, C. (1986). Discrimination of threat cues without awareness in anxiety states. *Journal of Abnormal Psychology*, 95, 131-138.
- McNally, R. J., Amir, N., & Lipke, H. J. (1996). Subliminal processing of threat cues in posttraumatic stress disorder? *Journal of Anxiety Disorders*, 10, 115-128.
- Mogg, K., & Marden, B. (1990). Processing of emotional information in anxious subjects. *British Journal of Clinical Psychology*, 29, 227-229.
- Monsell, S. (2003). Task switching. *Trends in Cognitive Sciences*, 7, 134-139.
- Murray, N. P., & Janelle, C. M. (2003). Anxiety and performance: A visual search examination of the processing efficiency theory. *Journal of Sport and Exercise psychology*, 23, 171-178.
- Neshat-Doost, N., Taghavi, R., Moradi, A., Yule, W., & Dalgleish, T. (1997). The performance of clinically depressed children and adolescents on the modified Stroop paradigm. *Personality and Individual Differences*, 23, 753–759.
- Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience*, 13, 25-42.
- Santos, R., & Eysenck, M. W. (2006). *State anxiety, task switching and performance*. Unpublished Manuscript, University of London at Egham.
- Schultz, L. T., & Heimberg, R. G. (2008). Attentional focus in social anxiety disorder: Potential for Interactive Processes. *Clinical Psychology Review*, 28, 1206–1221.
- Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the State–Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.
- Williams, J. M., Mathews, A., & MacLeod, C. (1996). The emotional Stroop task and psychopathology. *Psychological Bulletin*, 120, 3–24.