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No evidence of attentional bias in statistics anxiety

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Abstract

The role of attentional bias in statistics anxiety was explored through cognitive and affective tasks. Participants consisted of 76 (73.7% females) students in the James Cook University Psychology programs at the Australia (35.5%) and Singapore campuses (64.5%). Participants completed the emotional Stroop task and the dot probe task, and measures of statistics anxiety and social desirability. No evidence of attentional bias was found. This could be due several methodological reasons. Limitations and future research directions are discussed.

Keywords: statistics anxiety; attentional bias.

1. Introduction

1.1. Statistics Anxiety

Cruise, Cash and Bolton (1985) defined statistics anxiety "as the feelings of anxiety encountered when taking a statistics course or doing statistical analyses" (p. 92). Statistics anxiety was originally conceptualized as identical to mathematics anxiety (e.g., Schact & Stewart, 1990). However, subsequent research has shown statistics anxiety to be a related but distinct construct from mathematics anxiety (Baloğlu, 1999, 2004). This was also supported by statistics learning being conceptualized as second language learning (Lalonde & Gardner, 1993; Onwuegbuzie, 2003) rather than mathematics learning. Lastly, statistics anxiety is often conceptualized as a multidimensional construct consisting of three factors: (a) Interpretation Anxiety, (b) Test and Class Anxiety, and (c) Fear of Asking

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for Help (Papousek et al., 2012). Interpretation Anxiety refers to the feelings of anxiety encountered when interpreting statistical data. Test and Class Anxiety deals with the anxiety involved when attending a statistics class or when taking a statistics test. Lastly, Fear of Asking for Help assesses the anxiety experienced when seeking help.

The antecedents, effects, and interventions of statistics anxiety have been well documented. Reported antecedents of statistics anxiety include perfectionism (Onwuegbuzie & Daley, 1999), procrastination (Onwuegbuzie, 2004), and age (Bui & Alfaro, 2011). Statistics anxiety has often been conceptualized as a debilitative construct. A consistent negative relationship has been found between statistics anxiety and statistics achievement in a number of studies (e.g., Hanna & Dempster, 2009; Onwuegbuzie & Seaman, 1995). In other words, students who experience higher levels of statistics anxiety tend to have poorer performance on statistics assessments. Lastly, given the effects of statistics anxiety, a number of studies have been conducted to investigate the effects of interventions designed to reduce statistics anxiety among students. For example, instructors can use humor in class (Wilson, 1999), provide coping strategies to students (Pan & Tang, 2004), or increase their immediacy behaviors (e.g., addressing students by name) (A. S. Williams, 2010) to reduce students' levels of statistics anxiety. Nevertheless, despite the large number of investigations on statistics anxiety, the mechanisms by which statistics anxiety operate are unclear.

1.2. Cognitive Theories and Models

Since 1990, a large number of studies have examined the role of cognitive biases in anxiety. There are three types of cognitive biases: attentional bias, interpretation bias, and memory bias (see Beard, 2011; Hertel & Mathews, 2011; MacLeod & Mathews, 2012 for reviews). Among these biases, attentional bias has received the most research attention. Attentional bias toward threat is defined as the preferential allocation of attention towards threatening stimuli related to an individual's anxiety, relative to neutral stimuli (Cisler & Koster, 2010). Despite the existence of other cognitive theories (e.g., Eysenck, Derakshan, Santos, & Calvo, 2007) and models (e.g., Mogg & Bradley, 1998), studies on attentional bias have been primarily motivated by Beck's schema theory (Beck & Clark, 1988, 1997; Beck, 1976) and Bower's network theory (1981, 1987).

According to Beck and Clark (1988), "schemas are functional structures of relatively enduring representations of prior knowledge and experience" (p. 24). These cognitive structures guide information processing; individuals tend to elaborate or ignore stimuli consistent or inconsistent with existing schemas, respectively. Hence, individuals high in anxiety will favor the processing of emotionally threatening, anxiety-related stimuli. According to Bower (1981, 1987), emotions are stored as nodes in a network and they are connected to other nodes containing emotionally-congruent information. Individuals experiencing an emotional state will activate the relevant emotion nodes which, in turn, prime the associated nodes for subsequent processing. Therefore, individuals high in anxiety will favor the processing of anxiety-related stimuli in their environment. In addition to the common prediction that individuals with anxiety have an attentional bias toward threat, both theories assert that this bias plays an important role in the etiology and maintenance of anxiety. Accordingly, researchers have turned to a number of experimental paradigms to understand this bias.

1.3. Experimental Paradigms

Experimental paradigms for the study of attentional bias are divided into either interference or facilitation paradigms (Buckley, Blanchard, & Neill, 2000). Interference paradigms demonstrate how task performance is impaired due to attentional bias whereas facilitation paradigms demonstrate how task performance is enhanced due to attentional bias.

One of the most popular interference paradigms is the emotional Stroop task, an adaptation of a classic paradigm first introduced by Stroop (1935). In the Stroop task, participants name the color of the words while disregarding the content of the words. The emotional Stroop task varies in that the content of the words represent threat rather than color. Individuals with an attentional bias are slower to name the color of threatening words than neutral words. However, it has been suggested that the interference effects observed in the emotional Stroop task can be attributed to both attentional bias toward, and cognitive avoidance of, threat (De Ruiter & Brosschot, 1994). Although contemporary researchers continue to use the emotional Stroop task as a measure of attentional bias (e.g., Phelan et al., 2012), this limitation of interference paradigms has motivated other researchers to adopt facilitation paradigms.

The dot probe task (MacLeod, Mathews, & Tata, 1986) is one of the most popular facilitation paradigms. In the dot probe task, word pairs containing a threatening and a neutral word are presented on a screen and participants press a response key when a probe stimulus replaces one of the words. Individuals with an attentional bias are faster in responding to a probe stimulus that replaces a threatening word than a neutral word. The facilitation effects observed in the dot probe task are often interpreted as both vigilance for threat and a difficulty to disengage from threat (Koster, Crombez, Verschuere, & De Houwer, 2004).

Currently, researchers cannot agree whether the emotional Stroop task and dot probe task share the same underlying processes. Some studies found no relationship (Mogg et al., 2000) or a small positive relationship (Brosschot, de Ruiter, & Kindt, 1999) between the tasks and argued that they are different. However, one study found a moderate positive relationship and argued that the tasks might share some common underlying processes (Egloff & Hock, 2003). The lack of research interest in this area has thus far precluded an explanation of these discrepant results. Nevertheless, both the emotional Stroop task and the dot probe task have been used in a large number of studies among clinical and non-clinical populations.

1.4. Studies on Attentional Bias

Attentional bias has been examined in clinical populations. Such studies often compare levels of attentional bias between a clinical group and a matched control group. For instance, MacLeod et al. (2007) assigned participants who met the DSM IV criteria for generalized anxiety disorder to a clinical group (n = 24), and participants with no anxiety to the control group (n = 35). Participants completed the dot probe task online. Results showed that the clinical group was faster in responding to a probe stimulus that replaces a threatening word (e.g., suffer) than a neutral word (e.g., parked). In general, evidence of attentional bias has been documented among many types of anxiety disorders such as generalized anxiety disorder, panic disorder, post-traumatic stress disorder, and specific phobias (see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van IJzendoorn, 2007 for a review), but not for obsessive-compulsive disorder (OCD) (Harkness, Harris, Jones, & Vaccaro, 2009; Moritz & von Mühlenen, 2008).

Attentional bias has also been examined in non-clinical populations. Such studies often divide participants into two groups based on their anxiety scores and compare their levels of attentional bias. For instance, Egloff and Hock (2003) used a median split to divide 53 participants into low (n = 26) and high anxiety (n = 27) groups based on their scores on the trait scale of the State Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970). Participants completed the emotional Stroop task and the dot probe task. Participants with high anxiety were faster in responding to a probe stimulus that replaces a threatening word on the dot probe task, and slower in naming the color of a threatening word on the emotional Stroop task.

More relevant to the aims of the current study, the role of attentional bias in mathematics anxiety has been studied (Hopko, McNeil, Gleason, & Rabalais, 2002). Participants were divided into two groups: low mathematics anxiety group (n = 17; bottom 20% in mathematics anxiety scores among an initial sample of 459) and high mathematics anxiety group (n = 25; top 20% in mathematics anxiety scores). Participants completed a card task and an emotional Stroop task. In the card task, participants counted the number of stimuli (either numbers or alphabets) on each card. In the emotional Stroop task, participants named the color of threatening (e.g., calculus) and neutral (e.g., fastener) words. Results showed that the high mathematics anxiety group took a longer time in counting numbers on the card task than their low-anxious counterparts. No significant difference was found for the emotional Stroop task.

1.5. The Current Study

Although little or no research has explored the role of attentional bias in statistics anxiety, the use of experimental paradigms has provided many insights into the role of attentional bias in a wide variety of psychological disorders (Bar-Haim et al., 2007; J. M. Williams, Mathews, & MacLeod, 1996). Thus, the same paradigms could be applied to statistics anxiety to further understanding of this construct. As recommended by De Ruiter and Brosschot (1994), the current study employed both the emotional Stroop task (interference paradigm) and the dot probe task (facilitation paradigm). Furthermore, a measure of social desirability was included as participants who are repressors (high in social desirability, low in anxiety) exhibit a different pattern of attentional bias than participants who are truly low anxious (low in social desirability, low in anxiety) (Derakshan, Eysenck, & Myers, 2007; Ioannou, Mogg, & Bradley, 2004).

The purpose of the current study is to bridge the research gap by exploring the role of attentional bias in statistics anxiety. It is hypothesized that participants with higher statistics anxiety will be slower to name the color of a threatening item on the emotional Stroop task than their low-anxious counterparts (interference hypothesis). It is also hypothesized that participants with higher statistics anxiety will be faster in responding to a probe stimulus that replaces a threatening item on the dot probe task than their low-anxious counterparts (facilitation hypothesis).

2. Methods

2.1. Participants

Participants consisted of 76 (73.7% females) students in the James Cook University Psychology programs at the Australia (35.5%) and Singapore campuses (64.5%). Their ages ranged from 18 to 50 years (M = 24.05, SD = 7.65). Participants were either currently enrolled in a statistics course (86.8%) or had completed at least one statistics course but were not currently enrolled in a statistics course (13.2%). All participants had normal or corrected-to-normal eyesight and were not color blind.

2.2. Stimuli Generation and Evaluation

A total of 65 pairs of words and 30 pairs of symbols were generated. Threatening words and symbols related to statistics were generated from an introductory statistics textbook (Gravetter & Wallnau, 2007). Thirty-one threatening words were matched for letter length and frequency of usage with neutral words according to a frequency dictionary (Davies & Gardner, 2010). Threatening words not found in the frequency dictionary (e.g., Factorial) were paired and matched for letter length with neutral words (e.g., Decanting) adapted from MacLeod et al. (2002). Threatening symbols (e.g., R^2) were matched with neutral symbols (e.g., =) found on a standard QWERTY keyboard.

Eight final-year psychology students completed the Background Information Form and rated a total of 130 words and 60 symbols, presented in random order, on a 9-point scale that ranged from 1 = *Very Negative* to 5 = *Neutral* to 9 = *Very Positive* (MacLeod et al., 2002) on SurveyGizmo (2013), an advanced online survey software. Threatening stimuli with a mean rating of less than 4.63 and the corresponding neutral stimuli (mean rating between 5.0 and 6.6) were retained. This resulted in 72 words and 24 symbols (see Appendix). Threatening words (M = 4.13, SD = .37) were rated more negatively than neutral words [M = 5.87, SD = .40, t (70) = -19.09, p < .001] and threatening symbols (M = 4.16, SD = .34) were rated more negatively than neutral symbols [M = 5.84, SD = .28, t (22) = -13.15, p < .001].

2.3. Tasks

In the emotional Stroop task, participants saw a fixation point (+) in the center of the screen for 500 milliseconds followed by a stimulus (word or symbol) that remained on the screen until a response were made. There was a 500 millisecond interval between each trial. Each stimulus was randomly presented in one of four colors and participants responded using response keys which corresponded to the color of the stimulus ('D' for red, 'F' for green, 'J' for blue, and 'K' for yellow). Keyboard response was used instead of vocal response to increase similarity in response modes between the emotional Stroop task and the dot probe task (Egloff & Hock, 2003). Participants completed 10 practice trials to familiarize with the task before completing 96 experimental trials (72 words and 24 symbols). An error message (a red 'X') was provided in practice trials but not in experimental trials.

In the dot probe task, participants saw a fixation point (+) in the center of the screen for 500 milliseconds followed by a pair of stimuli randomly presented one above the other for 500 milliseconds which were then followed by a probe stimulus (either 'F' or 'J') randomly presented in either the top or bottom location. The probe stimulus remained on the screen until a response was made. There was a 500 millisecond interval between each trial. Participants responded using response keys which corresponded to the type of probe stimulus (either 'F' or 'J'). The probe stimulus replaced the threatening stimuli in congruent trials and the neutral stimuli in incongruent trials. Participants completed 10 practice trials to familiarize with the task before completing 96 experimental trials (36 pairs of words and 12 pairs of symbols). An error message (a red 'X') was provided in practice trials but not in experimental trials.

2.4. Instruments

The Statistical Anxiety Rating Scale, commonly known as the STARS, is a 2-part, 51-item instrument designed to assess six factors of statistics anxiety (Cruise et al., 1985). Recent research suggested that part one of the STARS (the first three factors) assesses statistics anxiety whereas part two of the STARS (the last three factors) assesses attitudes toward statistics (Papousek et al., 2012). Hence, only part one of the STARS was used in the current study.

Part one consists of 23 items which assess statistics anxiety associated with situations where students have contact with statistics and it includes the following factors: (a) Interpretation Anxiety (e.g., figuring out whether to reject or retain the null hypothesis), (b) Test and Class Anxiety (e.g., doing the final examination in a statistics course), and (c) Fear of Asking for Help (e.g., asking a fellow student for help in understanding a printout). Participants respond on a 5-point Likert scale that ranges from 1 = *No Anxiety* to 5 = *Strong Anxiety*. Appropriate item scores are summed for each factor, with higher scores indicating higher levels of statistics anxiety. Cruise et al. (1985) reported internal consistencies that ranged from .85 to .91 (n = 1150) and five-week test-retest reliabilities that ranged from .72 to .83 (n = 161) for the three factors. More recently, Papousek et al. (2012) reported internal consistencies that ranged from .86 to .88 (n = 400) and five-months test retest reliabilities that ranged from .49 to .76 (n = 89) for the three factors.

The current study used a revised version of the STARS. Hanna et al. (2008) revised six items to facilitate understanding by students in the United Kingdom. The revised version was chosen due to the relative similarity in language use between the Australia/Singapore sample and the United Kingdom sample. For example, the word "car" is used in both Australia/Singapore and the United Kingdom instead of the word "automobile".

The Marlowe-Crowne Social Desirability Scale is a unidimensional, 33-item instrument designed to assess social desirability or defensiveness (e.g., I am always courteous, even to people who are disagreeable) (Crowne & Marlowe, 1960). Responses are made on a True/False scale. Negative items are reverse scored and the items are summed to produce a single score, with higher scores indicating higher levels of socially desirable responding. The instrument was administered as a "Personal Reaction Inventory" to mask the true purpose of the instrument.

Crowne and Marlowe (1960) reported an internal consistency of .88 (n = 39) and a four-week test-retest reliability of .89 (n = 31) for the scale. More recently, Loo and Loewen (2004) reported an internal consistency of .75 (n = 663) for the scale. The scale has been used to discriminate repressors from participants who are truly low anxious (Ioannou et al., 2004; Mogg et al., 2000; Newman & McKinney, 2002).

2.5. Procedure

Participants completed the emotional Stroop task and the dot probe task (MacLeod et al., 1986) online using INQUISIT 4.0 (2013). INQUISIT measures reaction time with millisecond accuracy (De Clercq, Crombez, Buysse, & Roeyers, 2003). Both tasks took about 30 minutes to complete. Subsequently, participants completed the Background Information Form, the Statistical Anxiety Rating Scale (Cruise et al., 1985), and the Marlowe-Crowne Social Desirability Scale (Crowne & Marlowe, 1960) on SurveyGizmo (2013), an advanced online survey software. Each instrument took about 10 minutes to complete. Except for the Background Information Form, all instruments and tasks were counterbalanced to control for order effects.

3. Results

All results were analyzed using SPSS version 16.0. Alpha level was set at .01 to reduce the chance of Type 1 errors due to multiple comparisons. The means and standard deviations of the STARS (Cruise et al., 1985) and the social desirability scale (Crowne & Marlowe, 1960) are presented in Table 1. With the mean divided by the number of items in each factor, the results showed that the current sample reported highest anxiety associated with Test and Class Anxiety.

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Table 1

Means, Standard Deviations, and Internal Consistency (Cronbach's alpha) of the First Three factors of the STARS and the Social Desirability scale

	Statistics Anxiety			
	Interpretation	Test	Fear	Social Desirability
M	30.17	28.12	9.93	16.09
SD	8.49	6.35	3.93	4.63
Cronbach's alpha	.90	.88	.88	.70
No. of Items	11	8	4	33
M / No. of Items	2.74	3.52	2.48	-
Actual Range	12-55	13-40	4-20	5-26
Potential Range	11-55	8-40	4-20	0-33

Note. Interpretation = Interpretation Anxiety; Test = Test and Class Anxiety; Fear = Fear of Asking for Help

A median split was used to classify participants into the Low Anxiety group and the High Anxiety group for the three factors of statistics anxiety (Cruise et al., 1985). Because a participant can be classified as Low Anxiety on one factor but High Anxiety on the other factors, different factors had different numbers of participants in each group. A series of *t*-tests showed that the Low Anxiety group had significantly lower anxiety associated with the respective factors than the High Anxiety group. The results are presented in Table 2. A series of *t*-tests and tests of independence showed that there were no significant differences between the Low Anxiety groups and the High anxiety groups in terms of age and gender distribution, respectively.

Table 1

Means and Standard Deviations of the Low Anxiety Group and the High Anxiety Group for the First Three Factors of the STARS

		Low Anxiety			High Anxiety				
Factors	Median	*n*	*M*	*SD*	*n*	*M*	*SD*	*t* (74) =	*p* value
Interpretation	30.50	38	23.74	5.39	38	36.61	5.65	-10.15	$p < .001$
Test	29.00	44	24.02	4.71	32	33.75	3.19	-10.73	$p < .001$
Fear	10.00	46	7.37	1.91	30	13.87	2.80	-12.03	$p < .001$

Note. Interpretation = Interpretation Anxiety; Test = Test and Class Anxiety; Fear = Fear of Asking for Help

Errors and outliers were removed from the RT data (Koster et al., 2004). The number of errors ranged from 0 to 21 (M = 5.24, SD = 3.97) for the emotional Stroop task and 0 to 27 (M = 6.26, SD = 5.35) for the dot probe task. Outliers were defined as RT shorter than 200ms or longer than 2000ms, and RT that deviated more than three standard deviations from each participant's mean RT. The number of outliers ranged from 0 to 14 (M = 2.68, SD = 2.30) for the emotional Stroop task and 0 to 6 (M = 1.30, SD = 1.23) for the dot probe task. Errors and outliers accounted for 8.1% of the data.

A Threat Bias Index (TBI) was calculated for both the emotional Stroop task and the dot probe task. In the emotional Stroop task, TBI was calculated by subtracting the mean RT for neutral stimuli from the mean RT for threatening stimuli. A positive TBI indicates interference in color naming of threatening stimuli compared to neutral stimuli (Mogg et al., 2000). In the dot probe task, TBI was calculated by subtracting the mean RT for congruent trials from the mean RT for incongruent trials. A positive TBI indicates vigilance for threat whereas a negative TBI indicates avoidance of threat (MacLeod et al., 2007).

The means and standard deviations of RT and TBI for the emotional Stroop task are presented in Table 3. A 2(Interpretation: Low and High) x 2(Test: Low and High) x 2(Fear: Low and High) between-subjects ANCOVA was conducted with social desirability as a covariate and TBI for words as the dependent variable. The results showed no significant effects for Interpretation, F (1, 67) = 3.07, p > .01, Test, F (1, 67) = 0.57, p > .01, Fear, F (1, 67) = 0.20, p > .01, and social desirability, F (1, 67) = 0.22, p > .01. A similar analysis was conducted with TBI for symbols as the dependent variable. The results showed no significant effects for Interpretation, F (1, 67) = 1.57, p > .01, Test, F (1, 67) = 0.47, p > .01, Fear, F (1, 67) = 0.09, p > .01, and social desirability, F (1, 67) = 0.39, p > .01.

Table 2

Means (Standard Deviations) of RT and TBI for the Emotional Stroop Task

	Interpretation Anxiety		Test and Class Anxiety		Fear of Asking for Help	
	Low	High	Low	High	Low	High
Words						
Threatening	727.29	698.97	717.63	706.95	688.86	750.34
	(158.34)	(188.99)	(167.20)	(184.92)	(162.03)	(187.02)
Neutral	707.49	700.756	700.67	708.86	674.19	750.02
	(132.22)	(195.92)	(148.21)	(190.27)	(147.72)	(183.98)
TBI	19.81	-1.79	16.96	-1.91	14.67	0.33
	(63.11)	(45.60)	(57.44)	(52.27)	(60.20)	(47.83)
Symbols						
Threatening	753.91	741.11	744.71	751.36	727.41	778.34
	(147.73)	(203.10)	(168.34)	(189.86)	(160.97)	(196.86)
Neutral	750.00	752.54	755.39	745.61	735.87	774.89
	(179.30)	(190.18)	(184.43)	(185.21)	(179.49)	(190.31)
TBI	3.92	-11.43	-10.68	5.76	-8.46	3.45
	(83.75)	(82.73)	(79.46)	(88.11)	(79.47)	(89.14)

Note. TBI was calculated by subtracting the mean RT for neutral stimuli from the mean RT for threatening stimuli.

The means and standard deviations of RT and TBI for the dot probe task are presented in Table 4. A 2(Interpretation: Low and High) x 2(Test: Low and High) x 2(Fear: Low and High) between-subjects ANCOVA was conducted with social desirability as a covariate and TBI for words as the dependent variable. The results showed no significant effects for Interpretation, F (1, 67) = 1.47, p > .01, Test, F (1, 67) = 0.06, p > .01, Fear, F (1, 67) = 0.03, p > .01, and social desirability, F (1, 67) = 0.51, p > .01. A similar analysis was conducted with TBI for symbols as the dependent variable. The results showed no significant effects for Interpretation, F (1, 67) = 0.07, p > .01, Test, F (1, 67) = 4.56, p > .01, Fear, F (1, 67) = 0.08, p > .01, and social desirability, F (1, 67) = 2.14, p > .01.

4. Discussion

The purpose of the current study was to explore the role of attentional bias in statistics anxiety. It was hypothesized that participants with higher statistics anxiety will be slower to name the color of a threatening item on the emotional Stroop task than their low-anxious counterparts (interference hypothesis). It was also hypothesized that participants with higher statistics anxiety will be faster in responding to a probe stimulus that replaces a threatening item on the dot probe task than their low-anxious counterparts (facilitation hypothesis).

The results provided no support for both the interference hypothesis and the facilitation hypothesis. No evidence of attentional bias in statistics anxiety was found for the emotional Stroop task and the dot probe task. The results were similar to studies on OCD, where no evidence of attentional bias was found (Harkness et al., 2009; Moritz & von Mühlenen, 2008). Similar to OCD, the cognitive biases involved in statistics anxiety might be different from other anxiety disorders. For instance, other cognitive biases, such as interpretation bias and memory bias, might be more responsible for the etiology and maintenance of statistics anxiety. Nevertheless, this interpretation is unlikely since statistics anxiety appears to be more related to specific phobias than to OCD (Chew & Dillon, 2014). Therefore, the absence of attentional bias is more likely due to methodological reasons.

Table 3

Means (Standard Deviations) of RT and TBI for the Dot Probe Task

	Interpretation Anxiety		Test and Class Anxiety		Fear of Asking for Help	
	Low	High	Low	High	Low	High
Words						
Congruent	487.36	515.93	505.75	495.99	491.01	571.94
	(75.21)	(131.21)	(113.65)	(99.13)	(109.33)	(103.51)
Incongruent	490.11	510.94	506.29	492.73	490.59	515.76
	(76.49)	(133.06)	(108.86)	(108.78)	(104.10)	(114.55)
TBI	2.76	-4.99	0.45	-3.26	-0.42	-2.18
	(18.29)	(27.23)	(22.04)	(25.28)	(22.43)	(25.09)
Symbols						
Congruent	500.00	515.53	520.17	490.72	500.45	518.99
	(74.12)	(125.10)	(110.24)	(89.50)	(104.75)	(99.47)
Incongruent	506.35	523.91	517.58	511.77	503.10	533.58
	(71.63)	(133.97)	(105.60)	(110.66)	(98.74)	(118.05)
TBI	6.35	8.38	-2.59	21.05	2.66	14.58
	(37.82)	(41.37)	(36.48)	(39.64)	(36.43)	(43.15)

Note. TBI was calculated by subtracting the mean RT for congruent trials from the mean RT for incongruent trials.

First, statistics words and symbols might not be relevant to statistics anxiety. More relevant stimuli should be used by considering each factor of statistics anxiety individually. For instance, ego-threat words (e.g., failure, mistaken) (Egloff & Hock, 2001) might be more relevant for Interpretation Anxiety, examination-related threat words (e.g., stupidity, disgraced) (MacLeod & Rutherford, 1992) for Test and Class Anxiety, and social anxiety threat words (e.g., ridicule, scorned) (Helfinstein, White, Bar-Haim, & Fox, 2008) for Fear of Asking for Help anxiety.

Second, attentional bias might be suppressed if participants expect a threatening event (i.e., a suppression effect) (Amir et al., 1996; Helfinstein et al., 2008). For example, attentional bias was suppressed among participants with PTSD when they expect to watch a videotape about combat in Vietnam (Constans, McCloskey, Vasterling, Brailey, & Mathews, 2004). Since most of the participants in the current study were enrolled in a statistics course (86.8%), attentional bias might be suppressed because they expect to encounter statistics (e.g., lectures, homework, or test) in the near future.

Third, conducting the study online might have affected the results. Currently, most studies on attentional bias are conducted in a laboratory, with only a handful of studies conducted online (e.g., MacLeod et al., 2007). Anecdotal evidence suggests that participants are less motivated and focused in online studies. Indeed, the current study had a high percentage of errors and outliers (8.1%), and large standard deviations (up to 195.92 *SD*) compared to other studies (e.g., only 3% errors/outliers, and up to 110 *SD* in Egloff & Hock, 2003).

Limitations of the study should be noted. The sample size for the current study is small ($n = 76$). A post hoc power analysis showed an achieved power of .58 (Faul, Erdfelder, Buchner, & Lang, 2009). This was lower than the recommended power of .80 for Social Science research (Cohen, 1988). However, the sample size was comparable to other studies of attentional bias (Egloff & Hock, 2003; Hopko et al., 2002; MacLeod et al., 2007). Second, the small sample size precluded an investigation using extreme scorers (e.g., a comparison using the bottom and top 20% of statistics anxiety scorers). Nevertheless, the results showed that the Low Anxiety group had significantly lower anxiety than the High Anxiety group. Additionally, the use of the median split was consistent with studies that found evidence of attentional bias (e.g., Egloff & Hock, 2003).

Future research directions can be inferred from the current study. First, methodological concerns of the current study should be addressed. Specifically, future research could (a) use more relevant stimuli, (b) recruit as participants, students who have completed at least one statistics course but were not currently enrolled in a statistics course, to avoid the suppression effect, or (c) conduct the study in a laboratory. If attentional bias is absent despite addressing these concerns, future research could examine the role of other cognitive biases, such as interpretation bias and memory bias, in statistics anxiety.

5. References

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6. Appendix

Stimuli Pairs

Words (36 Pairs)		Symbols (12 Pairs)	
Statistics-Related	Neutral	Statistics-Related	Neutral
Statistics	Furniture	$\bar{y}$	%
Error	Brief	σ	*
Variable	Initial	Ɵ	)
Statistical	Preliminary	H_0	_
Factor	Beyond	H_1	‘
Estimate	Telephone	s_p^2	{
Calculation	Astronomer	$\bar{D}$	]
Analysis	Character	SS	}
Analyze	Jacket	df	\
*Parameter	Mythology	p	/
Quasi	Filed	$\hat{y}$	:
Histogram	Signature	R^2	=
Skewness	Textured		
Kurtosis	Fetching		
Median	League		
Variance	Feathers		
z-score	t-shirt		
Probability	Connections		
Alpha	Inner		
Beta	Note		
Power	Check		
t-test	e-mail		
Matched	Bridges		
Estimation	Transition		
ANOVA	AFAIK		
F-ratio	X-factor		
Posthoc	Keyhole		
Pairwise	Shearing		
Tukey	Confer		
Factorial	Decanting		
Coefficient	Centerpiece		
Regression	Everything		
Residual	Hallmark		
Chi-square	Pre-school		
SPSS	ASAP		
p-value	g-shock		

*Statistics-related words listed from here onwards are not found in the frequency dictionary (Davies & Gardner, 2010). Thus, most of the neutral words for these words are adapted from (MacLeod et al., 2002) and matched for length instead.