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The effects of physiological arousal on cognitive and psychomotor performance among individuals with high and low anxiety sensitivity

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Information-processing models of anxiety posit that anxiety pathology is associated with processing biases that consume cognitive resources and may detract from one's ability to process environmental stimuli. Previous research has consistently indicated that high anxiety has a negative impact on cognitive and psychomotor performance. Anxiety sensitivity, or the fear of anxiety and anxiety-related arousal sensations, is an anxiety vulnerability factor that has been shown to play a role in the development and maintenance of panic attacks and panic disorder. However, relatively little is known regarding the potential impact of anxiety sensitivity on performance. In the present study, 105 college students who scored either high (>24) or low (<14) on the Anxiety Sensitivity Index were randomly assigned to complete a series of arousal-induction tasks or no activity, followed immediately by three cognitive and psychomotor performance tasks: digit span - backward, math fluency, and grooved pegboard. Results indicated that participants with high anxiety sensitivity performed comparably to individuals with low anxiety sensitivity on each task, regardless of arousal level.

Anxiety sensitivity is the fear of anxiety-related sensations stemming from the belief that these sensations can cause physical, social, or psychological harm to the person (Reiss & McNally, 1985). Individuals with high anxiety sensitivity have a tendency to catastrophize sensations of physiological arousal, such as believing that heart palpitations are indicative of a heart attack. Consistent with other cognitive theories of anxiety (e.g., Clark, 1986), anxiety sensitivity theory posits that it is this cognitive misappraisal that results in anxiety and frequently leads to panic (Beck, Emery, & Greenberg, 1985). However, anxiety sensitivity theory is unique in that anxiety sensitivity is conceptualized as a relatively stable individual difference variable that can *precede* the onset of panic.

Considerable research has gathered support for this conceptualization of anxiety sensitivity and its relationship to anxiety, panic, and other psychological phenomena. Numerous studies have found that high levels of anxiety sensitivity are associated with the development of panic attacks and panic disorder (e.g., Maller & Reiss, 1992; Schmidt, Lerew, & Jackson, 1997; Schmidt, Zvolensky, & Maner, 2006). In one prospective longitudinal study, Anxiety Sensitivity Index (ASI) scores predicted the frequency and intensity of panic attacks 3 years later, with individuals who scored high on the ASI being five times more likely to meet criteria for an anxiety disorder during the 3-year period than those with low scores (Maller & Reiss, 1992). Similarly, Schmidt et al. (1997) conducted a series of prospective studies which indicated that anxiety sensitivity predicted the onset of panic attacks over a 5-week period of high stress (basic cadet training), even after controlling for a history of panic attacks and trait anxiety. In addition to predicting who will develop panic attacks, research has also demonstrated that high anxiety sensitivity is associated with the maintenance of panic attacks among individuals who have experienced panic in the past (Ehlers, 1995).

Anxiety sensitivity has also been linked with a variety of other psychological and behavioral phenomena. For example, biological challenge studies using participants with no history of panic have demonstrated that anxiety sensitivity is predictive of fearful responding to arousal induction via hyperventilation, caffeine, or 35% carbon dioxide inhalation (e.g., Harrington, Schmidt, & Telch, 1996; Schmidt & Telch, 1994). As a result of their fear of arousal symptoms, it has been suggested that individuals with high anxiety sensitivity may be more likely to avoid arousal-inducing stimuli (Reiss, 1991). Consistent with this assertion, individuals with high anxiety sensitivity have been shown to be more likely to avoid activities that arouse feared autonomic symptoms, such as physical exercise (e.g., McWilliams & Asmundson, 2001). In addition, adolescents and adults with high anxiety sensitivity tend to demonstrate increased motives for use, greater discomfort, shorter abstinence duration, and greater risk for relapse when substances such as alcohol, tobacco, and marijuana are discontinued (e.g., Bonn-Miller, Zvolensky, & Bernstein, 2007). Finally, high anxiety sensitivity has also been linked with the manifestation of other psychological conditions, including major depression (Schmidt et al., 2006) and substance abuse (e.g., Bonn-Miller et al., 2007; Schmidt et al., 2006).

Information-processing models of anxiety posit that anxiety involves selective processing of information perceived as threatening to personal safety and security (Beck et al., 1985). Consistent with this notion, studies have indicated that participants with high anxiety sensitivity have a tendency to interpret ambiguous stimuli and situations in a more threatening manner than those with low anxiety sensitivity (Liebman & Allen, 1995; Lilley & Cobham, 2005). In addition, individuals with high levels of anxiety sensitivity tend to pay more attention to threatening stimuli and have a memory bias for such information (e.g., McNally, Foa, & Donnell, 1989). Individuals with high anxiety sensitivity also show heightened interoceptive awareness, paying more attention to and more closely monitoring their arousal sensations (Pollock, Carter, Amir, & Marks, 2006). Some researchers have suggested that increased awareness of body sensations and arousal avoidance contributes to the maintenance of panic attacks (McNally, 2002).

The processing of threat-related information is thought to include automatic and controlled processes (McNally, 1995). Such processes consume valuable cognitive resources and may detract from one's ability to functionally address alternative environmental demands. Consistent with this notion, studies have consistently documented that cognitive and physical performance is negatively affected by high levels of anxiety in humans and animals (see Eysenck, Derakshan, Santos, & Calvo, 2007 for a review). For example, Hamilton (1978 as cited in Eysenck et al., 2007) found that highly anxious participants performed significantly more poorly on a digit-span test than low-anxious individuals, with it being interpreted as evidence that high-anxious individuals had less spare-processing capacity. High levels of anxiety have also been shown to negatively impact functioning on performance subtests of the Wechsler Adult Intelligence Scale (third edition; Hopko, Crittendon, Grant, & Wilson, 2005), as well as having a deleterious effect on performance of physical and motor tasks (e.g., Murray & Janelle, 2003). Further, evidence suggests that the association between trait anxiety and academic performance is mediated by verbal working memory (Owens, Stevenson, Norgate, & Hadwin, 2008), and high anxiety has a negative impact on working memory performance tasks (Rinck & Becker, 2005). Additionally, excessive anxiety appears to negatively affect perfor- mance, regardless of whether the task necessitates high or low cognitive functioning (Mullen, Hardy, & Tattersall, 2005).

Although research documenting the negative impact of high levels of anxiety on performance is substantial, researchers have yet to examine the potential impact of anxiety sensitivity on performance. However, there are several reasons to suggest that anxiety sensitivity may have a similar (or potentially greater) impact on performance in comparison with general anxiety. First, although research has demonstrated that anxiety sensitivity and trait anxiety are distinct constructs (McNally, 1996); significant overlap exists between these constructs. Specifically, several models describe anxiety sensitivity as a lower-order component of trait anxiety, and anxiety sensitivity has been shown to be highly correlated with trait anxiety (e.g., McWilliams & Cox, 2001). Second, individuals with high anxiety sensitivity have been shown to be particularly vigilant of their physical sensations, believing that these sensations may be associated with severe negative consequences (e.g., heart attack and suffocation). Thus, based on their attentional biases and fears of physical symptoms, high anxiety sensitivity individuals may experience greater difficulty attending to and concentrating on performance tasks, particularly under conditions of anxious arousal or physiological activation where they may be vigilant to their physiological sensations.

The purpose of the present study is to experimentally investigate the relationship between anxiety sensitivity and performance under conditions of high and low physiological arousal. It was hypothesized that anxiety sensitivity will have relatively little impact on cognitive and psychomotor performance under low-arousal conditions. However, when physiological arousal is induced, it was predicted that individuals with high anxiety sensitivity would perform more poorly on cognitive and psychomotor performance outcome measures than those with low anxiety sensitivity or no arousal.

Method

Participants

To be eligible to participate, individuals had to have either high (ASI score > 24; .5 standard deviation [SD] above the mean) or low (ASI score B 14; .5 SD below the mean) anxiety sensitivity and be: (1) in good physical health; (2) at least 18 years of age; and (3) not currently taking any illicit drugs or psychopharmacological medications (e.g., anxiolytic, Selective Serotonin Reuptake Inhibitor (SSRI)). The ASI cutoff scores employed for identifying high versus low anxiety sensitivity groups is consistent with cutoffs used in previous anxiety sensitivity research (e.g., Broman- Fulks, Berman, Rabian, &

Webster, 2004; Maller & Reiss, 1992). An a-priori power analysis revealed that a sample size of 32 per group (128 total) would be required to detect a medium effect size (*f* =.25), with 80% power, and alpha set at .05. Because, approximately 31% of individuals in a normative population would be expected to meet the>.5 SD criterion for high anxiety sensitivity and another 31% would be expected to meet the B.5 SD criterion for low anxiety sensitivity, a sample of approximately 200 needed to be screened to yield 128 qualifying participants. In an effort to ensure an adequate sample of participants who met inclusion criteria, approximately 250 participants were screened; however, fewer individuals with high anxiety sensitivity were identified than expected, yielding a final total of 105 participants who met all selection criteria, and reducing power to detect a medium effect size to approximately .72. To achieve the desired power level of .80, analyses were conducted using an adjusted alpha of .088.

The final sample included 105 undergraduate students (69 women and 36 men), ages 18-24 (*M* =18.87, SD = 1.27), who received course credit for their participation in the study. The majority of participants were Caucasian (90.5%), followed by a smaller representation of African-American (5.7%), Asian (1.9%), Hispanic (1%), and bi-racial (1%). Of the participants who completed the study, 18.1% reported a history of panic attacks. Only one participant (high anxiety sensitivity+ arousal condition) failed to complete the study due to feeling nauseated and faint after the arousal task. The consent process and research protocol were reviewed and approved by the Institutional Review Board for the Protection of Human Subjects at Appalachian State University.

Instruments

The ASI (Peterson & Reiss, 1992) is the most widely used measure of anxiety sensitivity and consists of 16 items designed to assess an individual's fear of anxiety and anxiety-related symptoms. Respondents are asked to indicate on a five-point Likert-type scale (0, very little; 4, very much) the extent to which they fear the possible negative consequences of anxiety-related sensations. The ASI is believed to assess a general higher-order anxiety sensitivity factor and three lower-order factors: (1) fear of physical symptoms; (2) fear of cognitive symptoms; and (3) fear of publicly observable symptoms (Zinbarg, Barlow, & Brown, 1997). The psychometric properties of the ASI are well established. The ASI has high internal consistency, with alpha scores ranging between .82 and .91, and is relatively stable, with a 2-week test-retest correlation of .75. The ASI has also been shown to possess adequate criterion-related validity (Reiss, Peterson, Gursky, & McNally, 1986).

The Acute Panic Inventory (API; Dillon, Gormon, Liebowitz, Fyer, & Klein, 1987) was used to assess clinical symptoms of panic (e.g., physiological arousal). The API consists of 17 items that are rated on a four-point Likert-type scale (0, *not present*; 3, *severe*) based on the presence of subjective symptoms. The API has been used extensively as a measure of subjective response to challenge exercises (e.g., Harrison et al., 1989).

Cognitive tests

According to the Processing Efficiency Theory (Eysenck & Calvo, 1992) and Attentional Control Theory (Eysenck et al., 2007), persons with high levels of anxiety must employ more cognitive resources in completing a performance task than individuals with low anxiety, which results in poorer performance and longer response times as the utilization of more resources decreases working memory capacity. Thus, the following cognitive tests were administered to assess the effects of arousal on a variety of cognitive performance abilities associated with working memory and timed performance.

The Digits Backward portion of the Digit Span subtest from the Wechsler Adult Intelligence Scale (third edition, WAIS-III; Wechsler, 1997) was administered to assess the effects of arousal on verbal working memory abilities. Previous research has demonstrated that verbal working memory mediates the relationship between anxiety and academic performance (Owens et al., 2008), and tasks that require working memory capacity are negatively impacted by high levels of anxiety (Hayes, MacLeod, & Hammond, 2009). Furthermore, studies have indicated that performance on Digits Backward in particular is negatively affected by high levels of anxiety (Wechsler, 1981). Administration of the Digits Backward subtest consists of an examiner reading a series of numbers, ranging from two to eight digits, after which examinees are asked to recall the digits, stating the numbers in reverse order. Participants' responses are recorded verbatim and the number of trials correct is scored by the examiner. Although the standard administration of the WAIS-III begins with strings of only two numbers, due to the high achievement level of the college student sample and need to maintain arousal during performance for individuals assigned to the arousal condition, administration began with four digits. The standard administration of the Digit Span subtest has excellent reliability (i.e., .90, Wechsler, 1997).

The Math Fluency subtest of the Woodcock-Johnson III Tests of Achievement (WJ III ACH; Woodcock, McGrew, & Mather, 2001) was administered to assess mathematic abilities under time pressure. Processing Efficiency Theory (Eysenck & Calvo, 1992) predicts that high anxiety is associated with slower cognitive processing, and research has indicated that shyness (a construct highly correlated with anxiety) is negatively associated with performance on timed tests of math abilities (Crozier & Hostettler, 2003). Furthermore, several studies have found that working memory is related to math performance (e.g., Ashcraft & Kirk, 2001). Math fluency requires participants to quickly solve 160 basic mathematics problems, and assesses numerical facility and speeded access to, and application of, arithmetic procedures. The Math Fluency test is a timed test, and participants are asked to complete as many math problems as they can in a 3-minute period of time. Scoring involves both accuracy and completion rate. The Math Fluency subtest of the WJ III ACH has excellent reliability, i.e., .90 (Woodcock et al., 2001).

Previous research has also suggested that individuals with high levels of anxiety perform more poorly on psychomotor performance tasks (e.g., Jain, 1986). In particular, studies have indicated that individuals with high levels of trait anxiety perform more poorly on tasks that require fine motor skills in comparison with their low-anxious counterparts (Calvo & Alamo, 1987). Thus, a Grooved Pegboard was used to measure the effects of anxiety sensitivity on fine psychomotor functioning under arousal conditions. The Grooved Pegboard consists of 25 small holes that have positioned slots, and the goal of the task is to insert the grooved pegs correctly into the slots in the quickest time possible. The pegs must be rotated to fit in the slots, which increases the level of complexity and fine motor dexterity required to complete the task. Participants were instructed to complete the task with their non-dominant hand followed by their dominant hand and to do so as quickly as possible. Time to completion was measured in seconds.

A paced breathing audio recording was utilized to induce arousal in participants by increasing the frequency of breaths taken per minute. The audio recording consists of prompts that instruct the participant to breathe at a rate of 30 respiratory cycles per minute for 3 minutes. This arousal-induction task has been shown to produce hyperventilation, physical symptoms of arousal, decreases in pCO_2, an elevation in blood pH, and increases in plasma epinephrine and lactate levels (Fried & Grimaldi, 1993), and has been used effectively in previous anxiety sensitivity research (e.g., Leen-Feldner, Feldner, Bernstein, McCormick, & Zvolensky, 2005).

A polar heart monitor was used to record the heart rate of the participants at eight time points over the course of the study. Specifically, heart rate was recorded at baseline, after the completion of the arousal or non-arousal tasks, after the completion of the cognitive or psychomotor tasks, and after the completion of all of the tasks. The heart monitor was used to verify arousal levels of participants throughout the experiment.

A brief demographic questionnaire was also administered to gather information on age, race, gender, health status, present drug and alcohol use, anxiety treatment history, and medication usage.

Procedure

Upon arrival to the laboratory, participants were informed that the study was designed to investigate mood states in college students and that a screening would take place to determine if they qualify for the study. Participants completed an informed consent document, demographic questionnaire, and the ASI. After completion of the forms, the experimenter determined whether inclusion criteria were met, and qualifying participants were scheduled to return to the lab at a later date. Participants who did not meet inclusion criteria were excused from the study and awarded credit for their time.

Upon their return to the lab, participants who met inclusion criteria were randomly assigned to an arousal-induction or non-arousal control condition using a random number generator. Participants were fitted with a heart monitor and asked to complete a series of psychological measures. Participants remained seated while completing the questionnaires, and baseline resting heart rate was recorded after participants had been seated for a minimum of 5 minutes. Participants were given directions for each of the three cognitive and psychomotor tasks prior to their completion of the arousal-induction or non-arousal task. The directions for the Digits Backward subtest were recorded verbatim from the WAIS-III manual and presented to participants via an iPod device, and one to two sample trials were presented as directed by the manual. The directions for the Math Fluency and Grooved Pegboard tasks were read verbatim by the experimenter from their respective manuals.

Following the directions for the performance tasks, participants were given instructions regarding the arousal-induction or non-arousal tasks, depending on which condition they were randomly assigned. Participants assigned to the arousal-induction condition listened to standardized audio-recorded instructions explaining the paced breathing exercise they would be completing. Instructions for the arousal task read verbatim from the script below, which has been utilized in previous research (Leen-Feldner et al., 2005):

> You will now be guided through a breathing exercise. In this exercise, you will be asked to breathe in and breathe out very deeply. The instructions will tell you when you should breathe in and when you should breathe out. Simply inhale when asked to ''breathe in,'' and exhale when asked to ''breathe out'' - making each breath in as deep as possible and each breath out as forceful as possible. It is important that you follow these instructions as best as you can, and continue the exercise until you are asked to stop and rest. (Leen-Feldner et al., 2005, p. 599)

The arousal-induction task consisted of a 3-minute breathing exercise presented via audio tape to participants who were seated. The experimenter remained in the room with participants, though out of sight, during the exercise to ensure participant adherence to the arousal-induction protocol. Any participant who did not adhere to the arousal-induction protocol was encouraged by the experimenter to follow along closely with the paced breathing exercise. In contrast, participants assigned to the non-arousal control condition sat quietly in a room without disturbance for 3 minutes to minimize stimulation prior to task completion and to make certain that both groups spent equivalent amounts of time in the laboratory. The experimenter remained in the room, though out of sight, with non-arousal participants to control for biases associated with experimenter contact. Heart rate measurements were recorded upon completion of the arousal-induction or non-arousal tasks, and participants were immediately presented with one of the three cognitive or psychomotor tasks in counterbalanced order. Upon completion of each task, heart rates were recorded. The arousal-induction or non-arousal tasks were repeated for each subsequent performance task.

Following completion of the three performance tasks, participants were administered the API and heart rates were recorded a final time. Participants were given the opportunity to be debriefed, the heart monitor was removed, and credit was awarded for their participation.

Results

To test the study hypotheses, two-way analyses of variance (ANOVAs) were computed for the three dependent variables, followed by Tukey's HSD post hoc analyses to examine group differences. As noted above, based on the sample size of 105, analyses were conducted using an adjusted alpha of .088 to increase statistical power to detect an effect to .80.

Preliminary analyses

One-way ANOVAs and chi-square tests indicated that the four groups were comparable at baseline on all demographic variables (all ps $>.10$; see Table 1). The

Table 1. Relevant demographic characteristics of high and low anxiety sensitivity participants by arousal condition.

	Low AS		High AS	
Variable	Arousal (n =29) M (SD)	Non-arousal (n =30) M (SD)	Arousal (n =24) M (SD)	Non-arousal (n =22) M (SD)
Age	18.68 (1.48)	18.90 (1.21)	18.92 (1.14)	18.77 (1.27)
Gender				
Men	11	15	5	5
Women	18	15	19	17
Race				
White	26	27	22	20
Black	1	2	1	2
Asian	1	0	1	0
Hispanic	1	0	0	0
Bi-racial	0	1	0	0
Panic history				
Yes	3	2	7	7
No	26	28	17	15
ASI baseline*	9.69 (3.32)	9.07 (3.40)	31.13 (5.84)	31.41 (6.11)

Note: AS, anxiety sensitivity; ASI, Anxiety Sensitivity Index. The ASI scores for the low anxiety sensitivity groups were significantly lower than the scores for the high anxiety sensitivity groups. However, the two low anxiety sensitivity groups did not differ from one another, nor did the two high anxiety sensitivity groups.
*p B.01.

results of a one-way ANOVA on baseline ASI scores indicated significant differences between the groups, $F(3, 100) = 177.75$, p B.001. Post hoc analyses revealed that the two low anxiety sensitivity groups scored significantly lower on the ASI than the two high anxiety sensitivity groups. However, the two low anxiety sensitivity groups did neither differ from one another, nor did the two high anxiety sensitivity groups.

Manipulation check

To ensure that the arousal-induction task produced the desired effect, participant heart rates were assessed immediately before and after each of the three arousal- induction or non-arousal tasks. Results of separate two (anxiety sensitivity) x two (arousal) x two (time) mixed model analyses of variance revealed a main effect for time for each of the arousal-induction tasks (see Table 2), with mean heart rates being higher on average at post than at baseline. A condition by time interaction was significant for each of the arousal-induction tasks (see Table 2). Post hoc analyses indicated that the two groups that completed the arousal-induction exercise had significantly higher heart rates at post than participants in the non-arousal conditions.

A MANOVA was used to test the effects of anxiety sensitivity and arousal level on heart rates. Results indicated a significant main effect for time from baseline to

Table 2. Heart rate by condition at baseline, following arousal induction or resting treatment, following the cognitive and psychomotor tasks, and post, and API scores at post.

Variable	Low AS		High AS	
	Arousal *M* (SD)	Non-arousal *M* (SD)	Arousal *M* (SD)	Non-arousal *M* (SD)
HR baseline	83.32 (10.99)	80.17 (11.44)	84.73 (8.36)	83.21 (10.50)
First HR arousal*	99.41 (15.98)	79.83 (12.03)	96.91 (11.12)	82.36 (8.74)
After first task	86.00 (12.19)	82.13 (11.27)	86.64 (6.05)	84.71 (11.02)
Second HR arousal*	95.18 (13.36)	77.75 (10.39)	91.82 (7.19)	80.29 (10.13)
After second task	82.90 (9.31)	80.25 (10.30)	86.64 (6.33)	82.64 (8.54)
Third HR arousal*	94.45 (11.52)	78.33 (11.87)	92.00 (11.82)	79.43 (8.29)
After third task	82.95 (9.57)	81.38 (11.55)	85.27 (8.66)	82.86 (8.03)
HR post	84.09 (10.58)	82.38 (11.20)	85.82 (8.30)	81.79 (8.48)
API scores post*	4.41 (3.48)	2.43 (2.91)	10.36 (7.14)	5.33 (3.35)

Note: HR, heart rate; AS, anxiety sensitivity; API, Acute Panic Inventory. Arousal denotes HR measurement following completion of the arousal-induction task or resting for. *p B.05.

the first arousal/non-arousal task by arousal, $F(3, 67) = 31.12$, p B.001, g_p^2 =.32. Furthermore, arousal was found to have a significant impact on heart rate after the performance task and after each of the other two arousal/non-arousal tasks, $F(3, 67) = 27.88$, p B.001, g^2 =.29; $F(3, 67) = 26.58$, p B.001, g^2 =.28, respectively (see Table 2). Overall, it was found that the heart rates of the arousal condition were significantly higher than the non-arousal condition. Anxiety sensitivity was not found to significantly affect any of the heart rate levels, p >.10, and no interaction effects were found, p >.10. It should be noted that baseline heart rate data were unavailable for 33 participants, who were thus excluded from manipulation check analyses. However, these participants did not differ from the analyzed sample in their heart rates at any of the subsequent time points (all ps>.10).

The API was administered to participants at post as a measure of subjective feelings and thoughts regarding panic during the arousal-induction or non-arousal tasks. A two-way ANOVA revealed significant differences in anxiety sensitivity, $F(1, 98) = 25.37$, p B.001, and arousal levels, $F(1, 98) = 15.92$, p B.001, with regard to API scores (see Table 2). High anxiety sensitivity individuals reported significantly higher levels of panic-related sensations than low anxiety sensitivity individuals. Also, individuals who completed the arousal-induction task reported significantly higher levels of panic-related sensations than the non-arousal individuals. The interaction effect was significant at the adjusted alpha level, $F(1, 98) = 3.01$, p =.08.

Effects of anxiety sensitivity and arousal on cognitive and psychomotor performance

Two-way ANOVAs were performed to test the effect of anxiety sensitivity (high/low) and arousal (high/low) on performance on cognitive and psychomotor tasks. Results revealed that performance, or items correct, on the Digits Backward cognitive task was not significantly affected by arousal level, $F(1, 104)=.001$, $p=.97$. However, results indicated that anxiety sensitivity level did significantly impact performance, $F(1, 104) = 4.13$, $p=.045$, $g^2=.04$ (see Table 3 for means and SDs for all performance tasks). Participants with low anxiety sensitivity performed significantly better on the Digits Backward task than participants with high anxiety sensitivity. The interaction effect for anxiety sensitivity and arousal levels was non-significant, $F(1, 104) = 1.63$, $p=.21$.

The effects of arousal on cognitive performance among individuals with high and low anxiety sensitivity were assessed via a second cognitive task, Math Fluency. Specifically, four aspects of performance on the Math Fluency subtest were analyzed, including the number of items correct, incorrect, completed, and time to completion (see Table 3). Results of a two-way ANOVA of Math Fluency items correct failed to indicate a significant main effect for arousal level, $F(1, 104)=.001$, $p=.98$, or anxiety sensitivity, $F(1, 104) = 2.26$, $p=.14$, and the interaction was non-significant, $F(1, 104)=.51$, $p=.48$. Similarly, a two-way ANOVA of Math Fluency items incorrect failed to indicate a significant main effect for arousal, $F(1, 104)=.21$, $p=.65$, or anxiety sensitivity, $F(1, 104)=.74$, $p=.39$, and the interaction was non-significant, $F(1, 104)=.33$, $p=.57$. Results of a two-way ANOVA of Math Fluency items completed also indicated non-significant main effects for arousal, $F(1, 104)=.003$, $p=.96$, or anxiety sensitivity, $F(1, 104) = 1.94$, $p=.17$, and the interaction was non-significant, $F(1, 104)=.36$, $p=.55$. A two-way ANOVA of Math Fluency time to completion failed to indicate a significant main effect for arousal, $F(1, 104)=.50$, $p=.48$, or anxiety sensitivity, $F(1, 104)=.00$, $p=1.0$, and the interaction was non- significant, $F(1, 104) = 1.06$, $p=.31$. Thus, performance scores on the Math Fluency subtest did not differ according to arousal or anxiety sensitivity levels.

Psychomotor performance was assessed via time to completion (seconds) on a Grooved Pegboard task using non-dominant (administered first) and dominant hands. A two-way ANOVA indicated that participant completion time on the Grooved Pegboard task using their non-dominant hand did not differ by arousal, $F(1, 104)=.22$, $p=.64$, or anxiety sensitivity level, $F(1, 104) = 62$, $p=.43$, and the interaction was non-significant, $F(1, 104)=.21$, $p=.65$. Similarly, analyses of the Grooved Pegboard task using dominant hand failed to indicate a significant main effect of arousal, $F(1, 104)=.00$, $p=.96$, or anxiety sensitivity level, $F(1, 104)=.06$,

Table 3. Means and standard deviations of scores on cognitive and psychomotor performance tasks by anxiety sensitivity and arousal level.

	Low AS		High AS	
Variable	Arousal ($n=29$) M (SD)	Non-arousal ($n=30$) M (SD)	Arousal ($n=24$) M (SD)	Non-arousal ($n=22$) M (SD)
Digits Correct	6.90 (1.68)	7.37 (1.75)	6.63 (1.93)	6.18 (1.97)
Math Correct	115.14 (21.25)	118.10 (16.83)	111.70 (23.72)	108.50 (26.41)
Math Incorrect	1.97 (1.70)	1.90 (2.54)	2.13 (2.30)	2.72 (4.71)
Math Complete	117.10 (20.98)	119.97 (16.80)	113.65 (23.71)	111.23 (27.66)

Math Time	179.52 (2.25)	179.30 (3.83)	178.83 (5.21)	180.00 (.00)
Pegboard Non-Dom Hand	77.45 (14.01)	79.67 (10.33)	76.67 (11.75)	76.68 (12.21)
Pegboard Dom Hand	64.10 (10.39)	67.00 (9.09)	66.58 (13.35)	63.45 (8.15)

Note: AS, anxiety sensitivity; Dom = dominant.

p =.80, and the interaction was non-significant, $F(1, 104) = 2.19$, p =.14. Thus, psychomotor performance, as assessed by the Grooved Pegboard, did not appear to be affected by arousal or anxiety sensitivity.

Exploratory analyses

To investigate whether evidence existed to suggest that the cutoffs for high and low anxiety sensitivity were too liberal, exploratory analyses were conducted using participants (n =57) who scored at least one SD above (29; n =28) and below (59; n =29) the non-clinical mean on the ASI. Results indicated that when using more conservative cutoffs, no main effects or interaction effects were found on any of the performance tasks (all ps>.19; see Table 4).

Discussion

Information-processing models of anxiety hold that anxiety involves selective processing of information perceived as threatening to personal safety and security (Beck et al., 1985), and such processing is thought to be automatic, but not resource free (McNally, 1995). Thus, individuals with anxiety pathology should demonstrate selective biases for threat information in attention, interpretation, and memory, and these cognitive processes should consume some of the brains resources. Consistent with this notion, Processing Efficiency Theory (Eysenck & Calvo, 1992) and Attentional Control Theory (Eysenck et al., 2007) suggest that highly anxious individuals must employ more cognitive resources in completing a performance task than individuals with low anxiety, which results in poorer performance and longer response times as the utilization of more resources decreases working memory capacity. Previous research has supported this conceptualization, indicating that extreme anxiety is indeed associated with both cognitive and physical performance impairments (e.g., Hopko et al., 2005; Mullen et al., 2005; Murray & Janelle, 2003; Rinck & Becker, 2005), presumably due to the interference of anxiety-related

Table 4. Means and standard deviations of scores on cognitive and psychomotor performance tasks by anxiety sensitivity and arousal level among participants who scored at least one standard deviation above or below the mean on the Anxiety Sensitivity Index.

	Low AS		High AS	
Variable	Arousal (n =13) M (SD)	Non-arousal (n =16) M (SD)	Arousal (n =15) M (SD)	Non-arousal (n =13) M (SD)
Digits Correct	7.07 (1.80)	6.81 (1.76)	6.73 (2.02)	6.31 (2.10)
Math Correct	111.00 (21.58)	116.25 (17.00)	111.50 (26.80)	106.00 (31.62)
Math Incorrect	2.08 (1.93)	2.00 (1.59)	1.29 (1.14)	2.54 (2.79)
Math Complete	113.08 (21.16)	118.19 (16.77)	112.50 (26.83)	108.54 (31.61)

Math Time	180.00 (.00)	180.00 (.00)	179.86 (.53)	180.00 (.00)
Pegboard Non-Dom Hand	76.76 (14.60)	79.75 (9.50)	79.20 (13.48)	73.62 (10.69)
Pegboard Dom Hand	65.54 (10.76)	67.19 (10.33)	69.00 (16.26)	61.08 (6.51)

Note: AS, anxiety sensitivity; Dom, dominant.

cognitive processes on one's ability to process additional information. Anxiety sensitivity is a facet of anxiety, and previous research has consistently demonstrated that individuals with high anxiety sensitivity show hypersensitivity to, avoidance of (McWilliams & Asmundson, 2001), and interpretational and attention biases (Lilley & Cobham, 2005) toward arousal sensations. However, the extent to which information-processing biases affect an individual with high anxiety sensitivity's ability to perform cognitive and physical tasks has not been previous addressed.

Contrary to study hypotheses, the results of the present study failed to provide evidence that anxiety sensitivity influences performance abilities under arousal- inducing conditions. Rather, results indicated that individuals with high anxiety sensitivity performed comparably to individuals with low anxiety sensitivity on cognitive and psychomotor performance tasks, regardless of arousal level. These findings are inconsistent with information-processing models of anxiety, which propose that when anxiety is induced, elaborative processing in the form of threat appraisal consumes a portion of the individual's cognitive resources, and thereby detracts from the individual's ability to perform concurrent cognitive tasks (Beck & Clark, 1997). Rather, these results appear to suggest that arousal induction among individuals with high anxiety sensitivity may be associated with automatic cognitive processing functions that do not pull cognitive resources necessary for simultaneous processing of alternative information.

Only one aspect of cognitive performance, number of digits backward items correct, was found to be significantly affected by anxiety sensitivity. However, no other cognitive or psychomotor tasks were found to be affected by anxiety sensitivity, even when more stringent anxiety sensitivity cutoffs were used. In addition, the implementation of more stringent cutoff scores resulted in a dissipation of the observed effect of anxiety sensitivity on digits backward performance. Thus, although it is possible that anxiety sensitivity may impact some cognitive processes such as verbal working memory, it is equally plausible that this finding represents a Type I error. Additional research will be required to evaluate these competing explanations.

Although participants with high anxiety sensitivity reported the highest levels of subjective distress according to their API scores following arousal induction, performance on the cognitive and psychomotor tasks appeared to be relatively unaffected. This finding is consistent with several previous studies that have found that highly anxious participants reported significantly more worry than low-anxious ones, though the groups did not differ in actual performance (e.g., Calvo, Alamo, & Ramos, 1990). It has been suggested that anxiety impairs performance efficiency more than performance effectiveness by reducing attentional control and impairing the inhibition and shifting functions involved in cognitive processing (Eysenck et al., 2007). Although the selection of performance tasks for the present study was theoretically driven, it is possible that these particular performance domains were not affected by arousal levels regardless of high anxiety sensitivity, though other performance domains more closely related to processing efficiency may be. Specifically, the performance tasks utilized in the present research included measures of verbal working memory, basic mathematical computation, and psychomotor speed. Although arousal may not significantly affect the performance of high anxiety sensitivity individuals on tasks that require relatively low levels of cognitive processing, tasks that require greater attention, concentration, and cortical processing may be affected. Indeed, some studies have found that high-trait anxiety is associated with performance impairments, but only in highly demanding tasks (e.g., Calvo et al., 1990). It is possible that the assessment instruments used in the present study may not have been sensitive enough to detect relatively small changes in performance. Future research utilizing tasks that necessitate greater levels of sustained attention, mental manipulation, and resistance to distraction or interference may provide further clarification regarding whether high anxiety sensitivity is associated with performance impairments.

Although this study provides initial evidence to suggest that anxiety sensitivity may not be associated with performance impairments, several study limitations influence the strength with which conclusions can be drawn. For example, it is possible that the participants in the present study did not adequately represent the extremes of high and low anxiety sensitivity. Although participants were pre-selected for high (ASI score] 24; .5 SD above the mean) or low (ASI score B14; .5 SD below the mean) anxiety sensitivity, it is possible that the cutoffs were too liberal for a non-clinical college sample. In an effort to test this possibility, exploratory analyses were conducted on a subsample of participants who scored at least one SD above and below the non-clinical mean on the ASI. However, results of these analyses failed to uncover any main effects for anxiety sensitivity or arousal levels, and all interaction effects were non-significant. Additional research may be warranted to further investigate whether anxiety sensitivity impacts performance at higher levels or among populations with anxiety disorder diagnoses.

The findings of the present research may also be partially attributable to the sample tested and/or power limitations. Participants consisted of a sample of relatively healthy, college students. Thus, it is possible that scores on the outcome measures may have been affected by range restriction due to the relative homogenous make-up and high-functioning nature of the groups. It is also possible that college students with high anxiety sensitivity may be less sensitive to arousal sensations experienced in performance situations due to repeated exposure to anxiety sensations associated with academic performance situations (e.g., test taking). Indeed, previous research indicates that repeated exposure to anxiety symptoms in the context of arousal- induction activities leads to less fear of anxiety-related sensations (e.g., Broman-Fulks et al., 2004). Future research into the potential effects of anxiety sensitivity on performance may benefit from the use of clinical or community samples, which may provide greater sensitivity for detecting performance effects. It is also worth to noting that the cell sizes in this study were relatively modest (n =22 to n =30), and future studies might incorporate larger groups to maximize statistical power to detect potential subtle effects of anxiety sensitivity on performance.

The present research utilized a well-validated hyperventilation challenge task for inducing feared arousal sensations among individuals with high anxiety sensitivity (e.g., Leen-Feldner et al., 2005), and a manipulation check indicated that individuals with high and low anxiety sensitivity who underwent arousal induction experienced a significant increase in heart rate compared to non-arousal individuals. The heart rate increase from baseline to arousal increased on an average of 10 beats per minute, which is consistent with previous research using a 2-minute hyperventilation exercise (Zvolensky et al., 2002), and participant scores on the API suggested that individuals who underwent the arousal exercise experienced significantly higher subjective anxiety regarding their arousal sensations. However, it is possible that the level of arousal generated by the induction task was not of sufficient strength to trigger information- processing biases and associated cognitive processes noted among individuals with high anxiety sensitivity. It is also possible that the administration of performance tasks following termination of the challenge task may have resulted in participants entering a recovery period following termination of the breathing exercise, and thus, the effects of the challenge task had begun to diminish. Future researchers may wish to address these issues by examining whether alternative arousal-induction techniques, such as caffeine or carbon dioxide inhalation, generate greater, more reliable increases in somatic arousal.

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