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Effects of Anxiety Sensitivity and Perceived Control on Emotional Responding to Caffeine Challenge

MICHAEL J. TELCH, PH.D., ANDREW SILVERMAN, M.A., AND NORMAN B. SCHMIDT, PH.D.

The University of Texas at Austin

Abstract — The effects of anxiety sensitivity and perceived control on emotional responding to a caffeine challenge were assessed in 72 subjects without a history of panic disorder. Subjects high and low in anxiety sensitivity (AS) were randomly assigned to either a perceived control (PC) or a no perceived control (NPC) instructional set. Compared to subjects low in AS, subjects high in AS displayed heightened emotional responding to the caffeine challenge. As predicted, high-AS subjects in the NPC condition displayed significantly greater emotional responding compared to high-AS subjects in the PC condition. In contrast, low AS subjects' emotional response to caffeine was not affected by the perceived control manipulation. Consistent with recent psychological formulations of panic, the present findings suggest that a fear of arousal (i.e., anxiety sensitivity) exerts a significant effect on emotional responding. Moreover, for those who display high anxiety sensitivity, greater emotional responding occurs when perceived control over arousal is low.

The "biological challenge" or "panic provocation" paradigm has been frequently used to investigate the pathogenesis of panic disorder. In this paradigm, a panic disordered group and a normal or psychiatric control group are administered a provocation that induces somatic sensations. Heightened challenge-induced emotional distress among the panic group has been frequently cited as supportive evidence for an underlying biologic vulnerability to panic disorder (Margraf, Ehlers, & Roth, 1986).

Numerous challenge agents have been shown to induce panic attacks in patients with panic disorder but rarely in normal controls. These include sodium lactate infusion (Cowley & Arana, 1990; Liebowitz et al., 1984), yohimbine

Correspondence and requests for reprints should be addressed to Michael J. Telch, Department of Psychology, Mezes 330, University of Texas, Austin, Texas 78712.

ingestion (Charney, Heninger, & Breier, 1984), carbon dioxide inhalation (Griez, de Loof, Pols, Zandbergen, Lousberg, 1990), caffeine ingestion (Charney, Heninger, & Jatlow, 1985), cholecystokinin tetrapeptide injection (Bradwejn, Koszycki & Shriqui, 1991), doxapram injection (Lee et al., 1993), and hyperventilation (Holt & Andrews, 1989). The sheer number and variety of challenges that differentially produce panic in PD patients, relative to controls, as well as the competing physiological effects of some of the challenge agents suggest that biological dysregulation is not a sufficient explanation for this differential response to challenge (Ehlers, Margraf, & Roth, 1986; Gorman, Papp, & Klein, 1990).

Panic provocation is being increasingly used to investigate psychological factors implicated in the psychopathogenicity of panic disorder. Since the tendency to respond fearfully to benign somatic cues figures prominently in contemporary theories of panic (Barlow, 1988; Beck & Emery; 1985; Clark, 1986), the administration of provocation agents that reliably induce intense somatic cues provides a useful vehicle for theory testing. Two specific predictions follow from this formulation. First, the theory predicts that any provocation agent capable of inducing somatic cues will be anxiogenic or panicogenic for those individuals who perceive the cues to be threatening. It would also follow that factors that heighten the perceived threat of challenge-induced arousal should increase the subject's emotional response to challenge, whereas factors that lower the perceived threat of challenge-induced sensations should decrease emotional responding.

Evidence in support of the first prediction comes from studies showing a linkage between "fear of fear" and panic disorder. To wit, there is increasing evidence that panic disorder patients show elevations on measures tapping fear of fear such as the Body Sensations Questionnaire (Chambless, Caputo, Bright & Gallagher, 1984), or the Anxiety Sensitivity Index (McNally & Lorenz, 1987; Reiss, Peterson, Gursky, & McNally, 1986). Anxiety sensitivity predicts the diagnostic severity of panic disorder (Jones & Barlow, 1991) and also distinguishes between mitral valve prolapse (MVP) patients with and without panic disorder (Lyons, Talano, Gitter, Martin, & Singer, 1986). Moreover, elevations in anxiety sensitivity normalize after cognitive-behavioral treatment for panic (McNally & Lorenz, 1987; Telch et al., 1993). However, it is possible that the elevation in anxiety sensitivity consistently seen in panic disorder samples serves not as a vulnerability factor in its development but rather as a concomitant or consequence of panic disorder.

Investigations using nonclinical populations have provided some support for the vulnerability hypothesis. For instance, compared to low-AS subjects, high-AS subjects displayed significantly higher anxiety and more severe physical symptoms in response to a hyperventilation challenge (Asmundson, Norton, Wilson, & Sandler, 1994; Donnell & McNally, 1989; Schmidt & Telch, 1994; Holloway & McNally, 1987). However, neither high- nor low-AS subjects panicked in response to hyperventilation challenge. This finding is consistent with

that of Rapee (1986) who also found that hyperventilation challenge heightened subjects' anxiety but failed to induce panic. Evidence that heightened anxiety sensitivity increases proneness to challenge-induced panic attacks in the absence of panic disorder comes from a recently completed study by Telch and Harrington (1993). Subjects with no history of panic who were high in anxiety sensitivity were 11 times more likely to panic in response to a 35% CO_2 inhalation than were subjects low in anxiety sensitivity.

The prediction that raising the perceived threat of challenge-induced sensations should lead to heightened distress has been investigated in several studies. Using an illusory control paradigm, Sanderson, Rapee, and Barlow (1989) demonstrated that compared to PD patients who received no illusion of control, those who were led to believe that they could control the concentration of CO_2 gas, displayed a significantly lower probability of CO_2-induced panic. Similarly, Rapee, Mattick, and Murrell (1986) found that in contrast to PD patients who were provided a full explanation of the effects of a 50% CO_2 inhalation, PD patients who were provided no such explanation displayed a greater proportion of catastrophic cognitions and a higher probability of panic. Insofar as subjects already had panic disorder, these findings leave open the possibility that factors such as perceived control or information about challenge-induced sensations exert their effects only for those already displaying panic disorder.

In the present experiment, we examined the effects of anxiety sensitivity and perceived control on the emotional response to a 450-mg caffeine challenge among subjects with no history of panic disorder. Several considerations led us to choose caffeine as the challenge agent. First, in sufficient doses (i.e., 400–800 mg) caffeine stimulates the autonomic nervous system by increasing the blood concentrations of epinephrine and norepinephrine (Robertson et al., 1978). Stimulation of the vagal, vasomotor, and medullary respiratory nuclei increases respiratory rate, oxygen intake, and carbon dioxide elimination (Sawyer, Julia, & Turin 1982). Second, caffeine induces somatic sensations including jitteriness, tremulousness, shakiness, and twitching (Goldstein, Karzer, & Warren, 1965). Third, caffeine has been shown to induce heightened emotional responding in panic disorder patients relative to controls (Beck & Berisford, 1992; Charney et al., 1985; Uhde, Boulenger, Vittone, Jimerson, & Post, 1984). Fourth, caffeine can be easily administered and thus serves as a safe and convenient challenge agent.

Perceived control over caffeine-induced arousal was manipulated by providing half of the subjects an ostensible "caffeine antidote" with instructions that they could ingest the antidote and counteract the caffeine should its effects become too uncomfortable (perceived control). The other half of the subjects were told that the effects of the caffeine, however unpleasant, would persist for several hours (no perceived control).

We hypothesized that subjects displaying the tendency to interpret arousal cues as threatening (i.e., high anxiety sensitivity) would display greater emotional

responding to caffeine compared to subjects low in anxiety sensitivity. We also hypothesized that the effects of perceived control would be moderated by anxiety sensitivity. Specifically, we predicted that perceived control would influence subjects' emotional response to caffeine only if they displayed high anxiety sensitivity.

METHOD

Subjects

Subjects were 35 male and 37 female students enrolled in introductory psychology classes at a large southwestern university. Subjects received course credit for their participation. Subjects were selected from a large pool (n = 7064) undergoing screening. Subjects ranged in age from 17 to 31 with a mean of 19.3 years (SD = 2.3). The following subject selection criteria were used: (a) Anxiety Sensitivity Index total score greater than 1 SD above (HAS) or below (LAS) the mean; (b) no history of medical conditions that could be aggravated by caffeine ingestion, including heart disease, kidney disease, hypertension, stroke, spastic colon, ulcers, arrhythmias, or pregnancy; (c) no current use of any contraindicated medication including bronchodilators, MAO inhibitors, Ritalin, long-acting decongestants, diet pills, birth control pills, or Antabuse; (d) intake of two or fewer cups of caffeinated coffee per day; and (e) no allergy to caffeine.

Experimental Design

A 2 × 2 completely randomized factorial design was used to test the singular and combined effects of anxiety sensitivity and perceived control. Subjects high and low on the Anxiety Sensitivity Index were randomly assigned to either a perceived control (PC) or a no perceived control (NPC) condition. Assessments of panic symptoms, subjective fear, negative affect, and positive affect were obtained at baseline and 75-min post caffeine ingestion.

Measures

Anxiety Sensitivity Index (ASI). The ASI (Reiss et al., 1986) is a 16-item self-report measure of the fear of bodily sensations associated with arousal. Each item consists of a possible negative consequence of anxiety symptoms. Items are rated on a 0- to 4-point Likert scale and are summed to compute a total score. The ASI has demonstrated high internal consistency and satisfactory test-retest reliability (Telch, Shermis, & Lucas, 1989).

Anxiety and Panic Questionnaire (APQ). The APQ (Telch, Lucas, & Nelson, 1989) is a 15-item self-report measure of panic attack and PD history. The APQ conforms closely to *DSM-III-R* diagnostic criteria and was based on the Structured Clinical Interview for the *DSM-III-R* (SCID; Spitzer, Williams, & Gibbon, 1987). The APQ has demonstrated adequate test-retest reliability and good agreement with interviewer administered SCID-R interviews (Telch et al., 1989).

Subjective Units of Distress (SUDS). Respondents' subjective overall level of anxiety was rated on a 0 (not at all anxious) to 10 (severely anxious) point Likert scale.

Positive and Negative Affect Schedule (PANAS). The PANAS (Watson, Clark, & Tellegen, 1988) is a 20-item self-report measure that consists of two 10-item scales, the first assessing current positive affect (PA), the second assessing current negative affect (NA). Items are rated on a 1 (very slightly or none) to 5 (extremely) point Likert scale. Each subscale is summed to compute a positive affect and a negative affect score. The PANAS has demonstrated adequate psychometric properties (Watson et al., 1988).

Bodily Symptoms Scale (BSS). The BSS is a 14-item scale for assessing bodily sensations associated with panic (Schmidt & Telch, 1994). These items correspond to each of the *DSM-III-R* symptoms of panic (e.g., palpitations, sweating, or trembling). Items are rated on a 0 (absent) to 4 (very severe) point Likert scale. Items were summed to create a total panic symptom index.

Assessment of challenge-induced panic. To classify caffeine-induced panic, a twofold criterion was used that required the subjective report of panic as well as the presence of four or more *DSM-III-R* panic attack symptoms indexed by the BSS. These criteria were utilized to capture the DSM requirements of intense fear plus the sudden onset of symptoms.

Procedure

A female undergraduate research assistant greeted each subject, who was informed that participation included the ingestion of 450 mg of caffeine. Following informed consent, the subject was screened to insure that (a) the ASI score remained greater than or less than 1 *SD* (i.e., cutoffs = 23 and 12, respectively) from the mean of all students; (b) there were no medical or medication contraindications to ingesting caffeine, including use of nicotine or birth control pills; (c) consumption of coffee (or its equivalent, e.g., tea, chocolate, soft drinks) was two or fewer cups, on average, per day; and (d) there was no history of panic disorder according to the APQ.

Once screening was completed, subjects completed the baseline assessment questionnaire packet (PANAS, BSS, SUDS) and were randomly assigned to the Perceived Control or No Perceived Control conditions.

Perceived Control (PC). Subjects assigned to the perceived control (PC) condition received the following instructions immediately prior to caffeine administration:

> This study deals with the effects of caffeine. You are going to take a dose of caffeine which may cause several physical and mental sensations associated with arousal. In the event that these sensations become too uncomfortable, we are making available to you this safe medication that will counteract the effects of the caffeine. We ask that you try your hardest to

refrain from taking the caffeine antidote. However, should your discomfort become too great, you may take the antidote to relieve your discomfort. Do you have any questions?

The ostensible caffeine antidote and a glass of water were left with the subject during the remainder of the experiment.

No Perceived Control (NPC). Subjects assigned to the no perceived control (NPC) condition received the following instructions immediately prior to caffeine administration:

This study deals with the effects of caffeine on mood and attention. You are going to take a dose of caffeine which may cause several physical and mental sensations associated with arousal. In the event that these sensations become too uncomfortable you are free to discontinue your participation in the study. We ask that you please try your hardest to complete the study. Keep in mind that whether or not you choose to discontinue participation in the study, the effects of the caffeine are likely to persist for several hours. Do you have any questions?

After being read the instructions, the subject ingested 450 mg of caffeine citrate dissolved in 6 oz. of Tang Breakfast Drink. This caffeine dose corresponds to approximately four cups of brewed coffee. Since caffeine reaches maximum blood concentrations in 15–120 min after ingestion (Leonard, Watson, & Mohs, 1987; Robertson et al., 1978), subjects were asked to sit or read quietly during the 75-min interval between caffeine administration and the postcaffeine assessment.[1] Subjects were debriefed after completing the postcaffeine questionnaire packet (PANAS, BSS, SUDS).

Statistical Analyses

The equivalence of the four experimental groups at baseline was examined using one-way analysis of variance (ANOVA) for continuous variables and chi-square analysis for categorical variables.

Two-way analyses of covariance (ANCOVA) were used to examine the singular and combined effects of anxiety sensitivity and perceived control on each of the outcome measures (i.e., PANAS, BSS, SUDS) at the post caffeine ingestion assessment period. The baseline measure of each dependent variable served as the covariate. One-tailed planned contrasts were conducted to test the specific experimental hypotheses.

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[1] All subjects consumed the Tang/caffeine solution. Emotional responding was also assessed 45-min post caffeine ingestion. Compared to the post 75-min assessment, subjects reported significantly fewer caffeine-related symptoms (e.g., nausea, palpitations, tremors) at the 45-min assessment. Since the integrity of a challenge task manipulation depends upon the arousal of sensations, we focused our analyses on the 75-min assessment period in which higher levels of symptoms were reported. However, the pattern of effects at the 45-min assessment period is consistent with those reported for the later assessment.

RESULTS

Precaffeine Assessment

Anxiety sensitivity. As expected, there was a significant difference in ASI scores among the four experimental conditions, $F(1,68) = 513.2$, $p < .01$. HAS subjects showed a mean ASI score of 30.4 ($SD = 5.9$) compared to a mean ASI score of 6.2 ($SD = 2.6$) for LAS subjects. Subjects in the two perceived control conditions did not differ significantly on the ASI (see Table 1).

Demographic variables. The demographic characteristics of subjects are presented in Table 1. There was a significant difference in sex ratio among the four groups — $\chi^2(3) = 6.52$, $p < .01$ — indicating more males in the LAS-PC condition compared to the other three groups. The four groups did not differ

TABLE 1
BASELINE COMPARISONS ON ANXIETY SENSITIVITY, DEMOGRAPHICS, AND CAFFEINE CONSUMPTION

	Experimental Condition			
Variable	HAS-PC ($n = 19$)	HAS-NPC ($n = 16$)	LAS-PC ($n = 20$)	LAS-NPC ($n = 17$)
ASI				
Mean	29.4[a]	31.6[a]	5.9[a]	6.5[a]
SD	5.3	6.6	2.7	2.5
Sex				
% Male	37[a]	25[a]	80[a]	47[a]
Age (years)				
Mean	19.0[a]	19.1[a]	19.3[a]	19.6[a]
SD	3.0	1.4	1.6	2.9
Weight (lbs)				
Mean	147.4[a]	139.5[a]	156.9[a]	144.6[a]
SD	43.2	19.6	29.5	18.8
Coffee/Day				
Mean	0.8[a]	1.2[a]	1.0[a]	1.0[a]
SD	0.7	0.5	0.7	0.6
Coffee/Today				
Mean	0.1[a]	0.2[a]	0.3[a]	0.1[a]
SD	0.3	0.4	0.5	0.3

Note: Means with different superscripts differ significantly. ($p < .05$).
ASI = Anxiety Sensitivity Index.
Coffee/Day = number of cups of caffeinated coffee consumed on average.
Coffee/Today = number of cups consumed on day of experiment.
HAS-PC: High anxiety sensitivity subjects in the perceived control condition.
HAS-NPC: High anxiety sensitivity subjects in the no-perceived control condition.
LAS-PC: Low anxiety sensitivity subjects in the perceived control condition.
LAS-NPC: Low anxiety sensitivity subjects in the no-perceived control condition.

significantly on age, weight, average caffeine consumption, or caffeine consumption on the day of the experiment.

Mood, symptom, and fear indices. Subjective distress and symptom measures are presented in Table 2. Compared to LAS subjects, HAS subjects reported significantly higher total panic symptom scores, $F(1,68) = 5.91$, $p < .05$; higher SUDS ratings, $F(1,68) = 15.11$, $p < .001$; and more negative affect on the PANAS-NA, $F(1,70) = 17.24$, $p < .001$, prior to caffeine ingestion. The HAS and LAS subjects did not differ with respect to positive affect as measured by the PANAS-PA measure. No other between-group comparisons were significant at the precaffeine assessment.

Emotional Response to Caffeine

A consistent pattern of findings emerged at the 75-min postcaffeine assessment (see Table 2). There was a significant main effect for anxiety sensitivity on all of the distress indices. Compared to LAS subjects, HAS subjects reported significantly higher panic symptom scores on the BSS, $F(1,66) = 7.00$, $p = .01$; significantly higher SUDS, $F(1,61) = 6.12$, $p < .05$; and significantly higher PANAS-NA scores, $F(1,66) = 5.53$, $p < .05$. There was no significant main effect of AS status on the positive affect index of the PANAS at the postcaffeine assessment.

As predicted, perceived control exerted a significant main effect on each of the distress variables. Compared to subjects in the PC condition, subjects in the NPC condition reported higher panic symptom scores, $F(1,66) = 4.42$, $p < .05$; higher SUDS, $F(1,61) = 4.03$, $p = .05$; and higher PANAS-NA scores, $F(1,66) = 4.27$, $p < .05$.

These main effects were qualified by interactions that approached significance for both panic symptoms, $F(1,66) = 3.16$, $p = .08$, and the PANAS-NA, $F(1,66) = 2.44$, $p = .12$. The ASI by Perceived Control interaction for the BSS and PANAS-NA is shown in Fig. 1. Results of the planned contrasts were consistent with prediction. HAS subjects in the NPC condition scored significantly higher than HAS subjects in the PC condition ($ps = .01$ and .03, for the BSS and PANAS-NA, respectively]. Similarly, subjects in the HAS-NPC condition reported higher SUDS scores than those in the HAS-PC condition, although this difference only approached significance, $F(1,33) = 3.86$, $p = .06$. As predicted, perceived control did not significantly influence level of symptoms, SUDS, or affect among the LAS subjects.

It should be noted that none of the subjects chose to take the "antidote."

Reported Panic

Only three subjects (4%) experienced a panic attack during the experiment. Of those subjects, two subjects (11%) were in the HAS-PC condition and one subject (6%) was in the HAS-NPC condition. None of the LAS subjects reported panic.

TABLE 2
MEANS, STANDARD DEVIATIONS, AND PLANNED CONTRASTS FOR SYMPTOMS, SUDS, AND AFFECT MEASURES AT BASELINE AND 75 MIN POST CAFFEINE INGESTION

	HAS-PC (n = 18)	HAS-NPC (n = 16)	LAS-PC (n = 20)	LAS-NPC (n = 17)	HAS-PC vs HAS-NPC (F Value)	LAS-PC vs LAS-NPC (F Value)
Symptoms (BSS)						
Precaffeine[a]						
Mean	4.2	5.6	0.6	0.5		
SD	8.5	13.2	1.2	0.9		
Postcaffeine[a,b]						
Mean	3.6	9.1	1.6	1.7	6.81*	*ns*
SD	3.9	10.6	2.6	1.8		
SUDS						
Precaffeine[a]						
Mean	3.1	2.1	0.5	1.4		
SD	2.1	1.6	1.2	1.4		
Postcaffeine[a,b]						
Mean	3.4	4.0	1.2	2.0	*ns*	*ns*
SD	2.3	2.5	1.4	2.1		
PANAS-NA						
Precaffeine[a]						
Mean	15.2	15.7	11.2	11.3		
SD	6.1	5.7	1.5	1.4		
Postcaffeine[a,b]						
Mean	13.9	17.6	11.9	12.1	5.06*	*ns*
SD	3.0	7.6	3.2	2.8		
PANAS-PA						
Precaffeine						
Mean	29.9	24.9	29.2	28.9		
SD	10.4	6.6	7.5	6.8		
Postcaffeine						
Mean	27.7	21.6	28.1	28.8	*ns*	*ns*
SD	9.1	8.1	8.2	9.0		

Note: HAS-PC: High anxiety sensitivity subjects in the perceived control condition.
HAS-NPC: High anxiety sensitivity subjects in the no-perceived control condition.
LAS-PC: Low anxiety sensitivity subjects in the perceived control condition.
LAS-NPC: Low anxiety sensitivity subjects in the no-perceived control condition.
[a]There was a significant main effect for group (HAS vs. LAS), $ps < .05$ (two-tailed).
[b]There was a significant main effect for perceived control (PC vs. NPC), $ps < .05$ (two-tailed).
*$p < .05$ (one-tailed).

Does a History of Panic Affect Responding to the Caffeine Challenge?

Because anxiety sensitivity is elevated among those with panic disorder (Chambless et al., 1984), we examined the extent to which a history of panic accounted for the increased subjective distress reported by HAS subjects. Based on data obtained from the APQ, 37% of the HAS subjects compared to

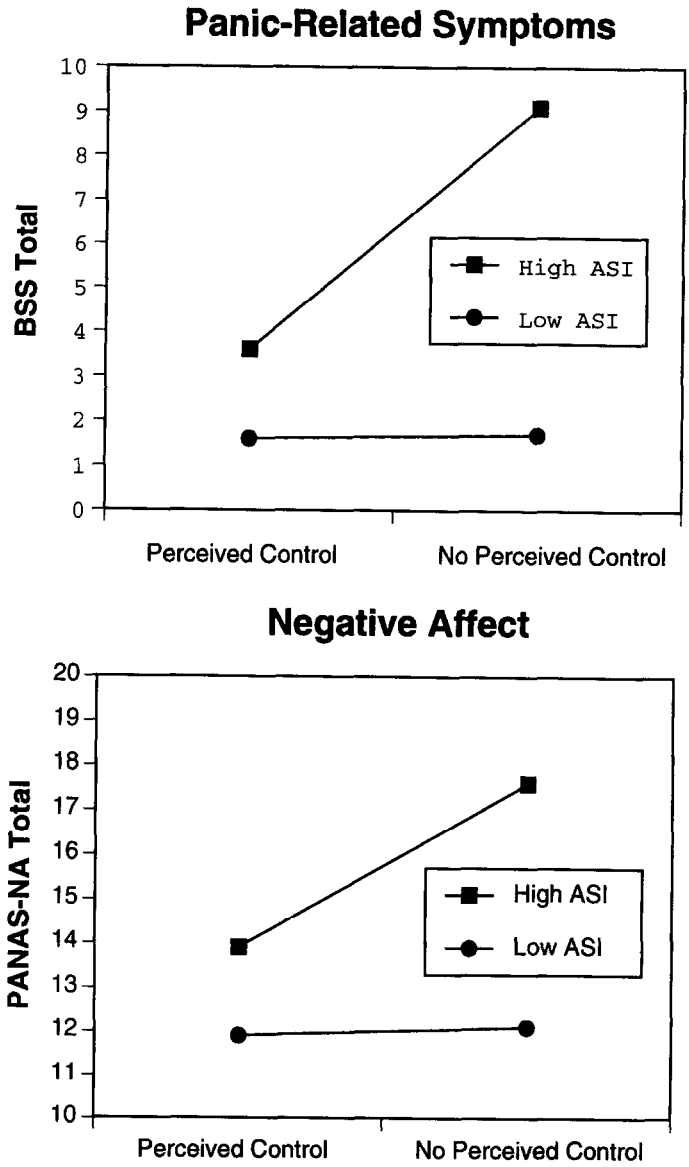

FIG. 1. THE EFFECTS OF ANXIETY SENSITIVITY AND PERCEIVED CONTROL ON SYMPTOMS AND NEGATIVE AFFECT FOLLOWING CAFFEINE INTAKE.

17% of the LAS subjects, reported at least one spontaneous panic attack during their lifetimes (see Table 1). Consistent with other reports, (Donnell & McNally, 1989; Schmidt & Telch, 1994), regression analyses revealed that panic history did not predict any of the indicators of emotional responding to caffeine after controlling for the effects of AS.

DISCUSSION

The present findings add to the existing knowledge base implicating anxiety sensitivity as a dispositional variable that increases fearful responding to provocations of arousal. Moreover, our results indicate that the effects of anxiety sensitivity are independent of subjects' history of panic. These results are consistent with the formulation that when one perceives arousal as threatening, one is more apt to respond fearfully to arousal-inducing agents and activities, regardless of one's prior history of panic attacks. These findings are in accord with those of Holloway and McNally (1987) and of Schmidt and Telch (1994), who found a similar effect of "fear of fear" on nonclinical subjects' response to a hyperventilation challenge.

A consistent, albeit weak, effect of perceived control on response to challenge was observed at the post 75 min assessment. This is consistent with the findings of Sanderson et al. (1989), which showed that the perception of control significantly attenuated panic disorder patients' emotional responding to CO_2 challenge, and with Barlow's (1988) contention that lack of perceived control may be an important factor mediating panic patients' response to challenge.

As predicted, the effects of perceived control on emotional responding was significant only for subjects high in anxiety sensitivity. This finding is consistent with the view that perceived control exerts its effects by reducing the perceived threat of challenge-induced arousal. Those subjects who perceive somatic cues of arousal as threatening are likely to find their distress diminished when they perceive that they can "turn off" the caffeine-induced arousal. Conversely, the enhanced sense of perceived control brought on by the availability of the caffeine antidote would be expected to exert little if any effect on caffeine-induced emotional responding among those subjects who already perceive the increase in arousal as nonthreatening.

Why did perceived control exert only a modest effect on emotional responding? Unlike CCK-4, yohimbine, and carbon dioxide gas, caffeine is a familiar substance to most people, and hence familiarity with the challenge agent may have attenuated its panicogenic capacity. Another possibility is that the perceived control manipulation was not perceived by some subjects as credible. However, during the debriefing, subjects were probed about their reactions to the experiment. It should be noted that no subjects in the perceived control condition actually took the antidote. None of the subjects questioned the credibility of the caffeine antidote.

It is also possible that the dose of caffeine used in the present experiment was insufficient to produce intense somatic sensations in all of our subjects. Close examination of the physical symptom severity data from the BSS revealed that while most subjects showed some increase in physical arousal, most subjects did not display a marked or extreme increase in bodily sensations in response to the 450 mg of caffeine. Zahn and Rapoport (1987) note that caffeine does not necessarily increase all indices of arousal and may change such indices in different ways for different subjects. In addition,

Sawyer et al. (1982) point out that both the rate at which caffeine is absorbed into the bloodstream and the rate at which it is transformed into nonactive agents varies across individuals. Thus, subjects who initially ingest the same amount of caffeine may differ considerably in their blood serum caffeine concentrations and consequently in their level of caffeine- induced arousal. Thus, insufficient arousal in some subjects may have attenuated the effects of the perceived control manipulation.

Providing subjects with explicit information about the effects of caffeine may have also attenuated fearful responding in the no control condition. Support for the fear-reducing effects of information on challenge-induced fear comes from several investigations (Rapee, Mattick, & Murrell, 1986; Schmidt & Telch, 1994). For instance, Schmidt and Telch (1994) found that compared to a group of nonclinical subjects who were given minimal information about what to expect during a hyperventilation challenge, subjects who were provided detailed information about the effects of hyperventilation displayed significantly less subjective anxiety and panic symptoms in response to the challenge.

Finally, Van den Bergh, Vandendriessche, De Broeck, and Van de Woestijne, (1993) found that the manipulation of perceived control instructions had no significant effect on normal subjects' subjective ratings of anxiety in response to a 5.5% CO_2 inhalation. However, the manipulation involved simply informing half the subjects that they could terminate the challenge at any time. Such instructions will be unsuccessful in creating differential levels of perceived control if most subjects already believe that discontinuation in the experiment is under their control.

Several limitations in our experiment deserve comment. First, the absence of a placebo challenge leaves open the possibility that AS and perceived control affected subjects' response to caffeine via their expectations of arousal as opposed to their actual arousal. Evidence that AS affects emotional responding via its effects on actual arousal comes from the Telch and Harrington (1993) CO_2 study in which both CO_2 and placebo (room air) were administered to subjects in a counterbalanced fashion. AS exerted a significant effect on subjects' response to CO_2 but not on subjects' response to room air.

Although increases in anxiety and negative affect were observed during the experiment, few of the subjects experienced a panic attack in response to caffeine ingestion. Any one of several factors may have contributed to subjects' failure to panic during the challenge. These include (a) an insufficient dose of caffeine, (b) instructions to subjects informing them of the likely effects of caffeine, and (c) perceived safety signals associated with the laboratory. However, previous challenge studies with nonclinical subjects have also shown low rates of actual panic despite significant increases in anxiety (Asmundson et al., 1994; Donnell & McNally, 1989; Holloway & McNally, 1987; Schmidt & Telch, 1994). Exceptions include the Telch & Harrington (1993) study, which used a 35% CO_2 challenge and the Koszycki, Cox, and Bradwejn (1993) study, which used a CCK challenge. The high rates of panic observed with these two

nonclinical samples raise an interesting issue with respect to the selection of provocation agents in research with nonclinical subjects.

Indeed, there appears to be marked differences in the sensitivity and specificity of the various panic provocation strategies studied to date when administered to nonclinical subjects. Our results and those from previous studies suggest that neither caffeine nor hyperventilation display sufficient sensitivity to provoke panic in nonclinical subjects. Recent findings suggest that CCK displays adequate sensitivity but low specificity in distinguishing nonclinical subjects high and low in anxiety sensitivity (Koszycki et al., 1993). In contrast, 35% CO_2 displays adequate sensitivity with nonclinical subjects and high specificity for distinguishing subjects high and low in anxiety sensitivity (Telch & Harrington, 1993).

Laboratory-based panic provocation strategies offer useful vehicles for identifying both biological and psychological factors implicated in the pathogenesis of panic disorder. In testing etiological theories of panic disorder, the application of this research paradigm with nonclinical subjects as opposed to panic disorder patients, offers the major advantage of controlling for the confounding effects of the disorder on subjects' response to the provocation agent. However, caution should be exercised in generalizing from laboratory-based research with nonclinical subjects to clinical patients with panic disorder. Use of alternative research paradigms such as longitudinal studies are needed to increase our confidence that potential risk factors identified in provocation studies are indeed associated with the later development of panic disorder.

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