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Discomfort Intolerance: Evaluation of Incremental Validity for Panic-relevant Symptoms Using 10% Carbon Dioxide-enriched Air Provocation

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Abstract

The present investigation examined the relation between discomfort intolerance and panic-relevant symptoms among 216 (117 women) young adults who participated in a biological challenge procedure. Partially consistent with hypotheses, after covarying for anxiety sensitivity, negative affectivity, and emotional acceptance, the intolerance subscale of the Discomfort Intolerance Scale (DIS; Schmidt et al., 2006) was significantly incrementally related to increased post-challenge anxiety focused on bodily sensations, physical panic symptoms, and behavioral avoidance, but not cognitive panic symptoms. Inconsistent with prediction, the avoidance subscale of the DIS was not significantly related to any of the dependent variables. Results are discussed in relation to better understanding the role of discomfort intolerance as a unique explanatory factor in the context of panic psychopathology.

Keywords

Discomfort Intolerance; Anxiety; Panic; Negative Affectivity; Biological Challenge; Avoidance

There has been an increasing scientific and clinical interest focused on evaluating the role(s) of various forms of tolerance for affective, psychological, and physical stressors in the etiology and maintenance of psychopathology (Gross, 1998; Hayes, Wilson, Gifford, Follette, & Strosahl, 1996; Zvolensky & Otto, 2007). For example, psychosocial treatments have been designed, in part, to modify such tolerance variables as a way to promote greater degrees of psychological health (Barlow, Allen, & Choate, 2004; Hayes, Strosahl, & Wilson, 1999; Linehan, 1993). Despite much scholarly and clinical interest in tolerance processes, broadly defined, there is surprisingly limited research that has evaluated the relations between (specific)

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tolerance variables and psychological symptoms and disorders. As a consequence, there is little empirical knowledge about the actual role of tolerance factors in mental health and psychological disorders more generally.

Although there are numerous tolerance variables proposed as being relevant to specific types of psychological problems (e.g., pain tolerance, affect tolerance, distress tolerance), *discomfort intolerance* has been theorized as one type of tolerance factor relevant to panic psychopathology. Discomfort intolerance is operationalized as individual differences relating to the capacity to withstand *uncomfortable physical sensations* (Schmidt & Lerew, 1998; Schmidt, Richey, Cromer, & Buckner, 2007; Schmidt, Richey, & Fitzpatrick, 2006). Thus, in contrast to constructs that are delimited to specific internal stimuli such as pain (Feldner, Hekmat, Zvolensky, Vowels, Secrist, & Leen-Feldner, 2006; Geisser, Robinson, & Pickren, 1992), discomfort intolerance has been conceptualized as relating to interoceptive (bodily) sensations that are uncomfortable, not necessarily painful, to the individual more generally. Past work has documented that discomfort intolerance is theoretically related to, but distinct from, other constructs such as distress intolerance, which indexes the degree of tolerance for negative emotional states (Simons & Gaher, 2005). It also has been conceptually distinguished from emotional or experiential avoidance that reflects individual differences in the unwillingness to experience aversive cognitions and affective states (Hayes et al., 1996).

The core conceptual idea driving discomfort intolerance work in relation to panic psychopathology is that persons less able to tolerate aversive physical sensations may be less able to withstand such stimuli and therefore escape or avoid situations (e.g., public settings) or activities (e.g., exercise) that may trigger them (Schmidt & Lerew, 1998). If such individuals high in discomfort intolerance consistently were unable to withstand physical stress and discomfort associated with fear and anxiety, and by extension escaped or avoided it, they may place themselves at greater risk for maladaptive panic-relevant learning. For example, greater ability to tolerate physical stress (e.g., bodily sensations) may theoretically permit certain people to experience exposure to unwanted and feared sensations. Such exposure is well-established as a method that can contribute to less avoidance and more rational cognitions rather than elevations in anxiety symptoms and cognitive distortions (Barlow et al., 2004). This type of perspective is consistent with integrative theoretical models and intervention strategies that attempt to modify anxiety and other problematic emotional states by changing one's response to aversive interoceptive (e.g., bodily sensations) and exteroceptive (e.g., stressful life occurrences) events (Hayes & Shenk, 2004; Orsillo, Roemer, & Barlow, 2003; Ramel, Goldin, Carmona, & McQuaid, 2004).

In order to empirically study the putative relation between discomfort intolerance and the onset and maintenance of panic and related anxiety disorders, Schmidt and colleagues (2006) developed the Discomfort Tolerance Scale (DIS). The DIS is a five-item self-report instrument that examines how much one can tolerate uncomfortable physical sensations. Factor analytic study, using principal axis factoring, has indicated that the DIS is comprised of a global higher-order discomfort intolerance factor and two sub-factors entitled Intolerance of Discomfort or Pain (e.g., "*I can tolerate a great deal of physical discomfort*" – *reverse scored*), and Avoidance of Physical Discomfort (e.g., "*I take extreme measures to avoid feeling physically uncomfortable*;" Schmidt et al., 2006). Although limited in overall scope, the DIS has thus far demonstrated sound psychometric properties (e.g., high levels of internal consistency as well as convergent and discriminant relations with other established constructs; Schmidt et al., 2006).

Schmidt and colleagues (2006) also have explored the associations between discomfort intolerance and panic and related symptoms using the DIS (Schmidt et al., 2006). In the earliest reported study, Schmidt and Lerew (1998) examined discomfort intolerance (global construct)

in relation to physical disability among a large sample of military cadets during basic training. Discomfort intolerance was significantly predictive of sick call (i.e., number of days not participating in training due to reported illness) among the cadets after statistically controlling for treatment history, physical fitness level, demographic factors (e.g., gender), and other psychological risk variables (e.g., anxiety sensitivity; McNally, 2002). In a separate two-part investigation, Schmidt and colleagues (2006) found that discomfort intolerance (global construct) was significantly elevated among those with panic disorder compared to control groups of clinically anxious individuals and persons with no history of axis I psychological disorders (Study 1). In Study 2 of this same report, Schmidt and colleagues (2006) examined the DIS in terms of its association with change in self-reported anxiety using a carbon dioxide (CO₂) challenge paradigm among clinical ($n = 45$) and non-clinical ($n = 45$) participants. Greater anxiety reactivity (pre-post change) was found among those scoring higher compared to lower on the DIS (global score) but only among the non-clinical sample (Schmidt et al., 2006). This body of work suggests that discomfort intolerance is related to anxiety reactivity to bodily sensations. In a subsequent and more recent test, Schmidt and colleagues (2007) examined discomfort intolerance in terms of responsivity to CO₂-induced bodily sensations among a nonclinical community sample with no history of panic attacks ($n = 44$). Results indicated that the global discomfort intolerance factor (DIS total score) was incrementally predictive of post-challenge self-reported anxiety above and beyond the variance accounted for by trait anxiety and anxiety sensitivity. When this association was further examined in follow-up analyses by entering each of the subscales of the DIS instead of the total score into separate regression equations (cf. simultaneous entry), the Avoidance of Physical Discomfort subscale demonstrated the strongest association with self-reported anxiety.

Extant work using the DIS suggests discomfort intolerance is related to anxiety-related symptoms, but the investigations in this regard are limited in number and scope. Although promising, there are at least three key limitations of existing research that warrant further study. First, previous tests have evaluated the cross-sectional and predictive explanatory value of individual facets of the discomfort intolerance, but not evaluated them in the same overarching model. That is, in regression equations evaluating the role(s) of DIS sub-factors in regard to panic problems, DIS sub-scales have been evaluated in separate regression models and have not yet been evaluated simultaneously in a single model that concurrently evaluates their shared and independent relations with the studied dependent variables. Given that the two facets of discomfort intolerance are empirically related to one another and both theoretically expected to be associated with panic symptoms (Schmidt et al., 2006), it is important to examine their respective effects in the context of one another. This type of test would help elucidate the unique explanatory value of each facet of distress intolerance for panic symptoms while explicitly considering their shared variance with one another.

Second, there have been only two tests that address the role of distress intolerance in terms of incremental validity for panic symptoms. In one study, baseline anxiety symptoms were used as a covariate (Schmidt et al., 2006), and in the other investigation, trait anxiety and anxiety sensitivity were evaluated (Schmidt et al., 2007). A more comprehensive test of discomfort intolerance in terms of panic symptoms could be attained if there was simultaneous covariation for a generalized tendency to experience negative mood rather than only anxiety symptoms (negative affectivity), anxiety sensitivity (for replication), and emotional acceptance. Each of these factors could represent higher-order constructs related to discomfort intolerance that could alternatively account for past findings linking distress intolerance to panic. For example, an individual prone to experience negative mood (e.g., sadness, anxiety, anger) may be *less* able to tolerate distressing physical sensations; likewise, individuals with a limited ability to tolerate physical distress may be more likely to experience negative affect. This type of perspective suggests that negative affectivity may share systematic associations with discomfort intolerance, although currently such relations have yet to be empirically tested.

Similarly, if an individual is hypersensitive and fearful of anxious internal sensations (anxiety sensitivity), then, they may be *less* able to tolerate various forms of physically uncomfortable or distressing sensations. And finally, a person who has a greater capacity to embrace adverse events (emotional acceptance) may have greater levels of tolerance for distressing physical sensations or vice versa. It is not empirically clear as of yet whether discomfort intolerance is distinguishable from emotional acceptance. Thus, it is possible that the variance these constructs theoretically may share explains previously observed associations between distress intolerance and panic. Overall, the relevance of discomfort intolerance for models of panic vulnerability would be significantly strengthened if this construct and its lower-order factors accounted for variance above and beyond negative affectivity, anxiety sensitivity, and emotional acceptance.

A final limitation of past work pertains to two methodological features of past biological challenge studies addressing discomfort intolerance. First, the sample sizes were rather limited in both investigations (Schmidt et al., 2006, 2007). Thus, expanding the sample size would lend confidence in the generalizability and stability of past observed effects. Additionally, it would be useful to extend the study of discomfort intolerance to avoidance of physical sensations, a behavioral process central to models of panic vulnerability (Zvolensky & Otto, 2007). Theoretically, to the extent discomfort intolerance is related to panic vulnerability, it should be associated with a tendency to avoid (aversive) physical sensations (Schmidt et al., 2007). Yet, the DIS has not thus far been studied in relation to panic-related avoidance processes.

Together, the purpose of the present investigation was to provide a comprehensive evaluation of the relation between the two identified lower-order factors of the higher-order discomfort intolerance construct and anxious and fearful responding to a biological challenge. It was hypothesized that after controlling for negative affectivity, anxiety sensitivity, and emotional acceptance, Intolerance of Discomfort or Pain and Avoidance of Physical Discomfort (the two facets that comprise the global discomfort intolerance construct) would each be independently associated with: (1) greater self-reported change in anxiety focused on bodily sensations; (2) greater post-challenge physical and cognitive panic symptoms; and (3) less willingness to participate in a future biological challenge after exposure to a 10% carbon dioxide enriched-air (CO₂) provocation (a behavioral measure of avoidance). These hypotheses were based upon past work that has indicated that each subscale is related to panic symptoms (Schmidt et al., 2006) and theoretical models of discomfort intolerance that suggest the facets of the construct should be related to multiple indices of panic vulnerability (Schmidt et al., 2007).

Method

Participants

A total of 216 participants (117 women; age $M = 20.7$ years, $SD = 7.0$) as recruited through the general community in Vermont via flyer placement in a local well-traveled marketplace, local restaurants, and university-based bulletin boards and classrooms. The racial and ethnic composition reflected that of the local population (State of Vermont Department of Health, 2000): approximately 95% of participants identified as white/Caucasian, 1% identified as Hispanic, 1% as Asian, 1% as Black, 1% as biracial and 1% did not report on their race/ethnicity.

Exclusionary criteria for the investigation included: (1) current axis I psychopathology; (2) current use of psychotropic medication; (3) current suicidality or homicidality; (4) current or past chronic cardiopulmonary illness (e.g., chronic obstructive pulmonary disease; severe asthma); (5) current acute respiratory illness (e.g., bronchitis); (6) seizure disorder, cardiac dysfunction, or other serious medical illness (e.g., history of seizures, emphysema); (7)

pregnancy (females); and (8) limited mental competency (not oriented to person, place, or time) or inability to give informed, written consent. These screening criteria were employed to protect participants by decreasing the probability of unanticipated medical complications resulting from CO₂ inhalation (Zvolensky & Eifert, 2000). Psychiatric history and psychotropic medication usage were measured by the Structured Clinical Interview-Non-Patient Version for DSM-IV (SCID-NP; First, Spitzer, Gibbon, & Williams, 1995). Medical exclusionary criteria were assessed within the context of the SCID interview using a supplemental set of (standardized) interview-based medical screening questions. This screening approach has been successfully used in past biological challenge work (Zvolensky, Leen-Feldner et al., 2004). Inter-rater reliability in our laboratory has been high for Axis I diagnoses (e.g., Zvolensky, Leen-Feldner et al., 2004). In the present study, each SCID was reviewed by the third author (A.B.) to ensure inter-rater agreement. No disagreements regarding inclusion/exclusion were observed. In addition to the current sample, 64 individuals were recruited but later excluded from the present investigation because they met the exclusionary criteria.

Measures

Pre-challenge measures—The *Structured Clinical Interview-Non-Patient Version for DSM-IV* (SCID-NP; First et al., 1995) was used to assess the presence of current AXIS-I psychopathology. The SCID-NP was used as subjects in the study were not identified as being a clinical population per se.

The Discomfort Tolerance Scale (DIS; Schmidt, Richey, & Fitzpatrick, 2006) is a 5-item measure on which participants indicate, on a 7-point Likert-type scale (0 = *not at all like me* to 6 = *extremely like me*), the degree of agreement towards statements related to their tolerance of discomfort. Aside from a global score, factor analysis indicates that the DIS is comprised of two distinct sub-factors entitled Intolerance of Discomfort or Pain (2 items; e.g., “*I can tolerate a great deal of physical discomfort*” – *reverse scored*), and Avoidance of Physical Discomfort (3 items; e.g., “*I take extreme measures to avoid feeling physically uncomfortable*”). The DIS has good internal consistency with alpha coefficients being .91 for the Intolerance subscale and .72 for the Avoidance subscale (Schmidt et al., 2006, 2007).

The *Positive Affect Negative Affect Scale* (PANAS) is a 20-item measure in which respondents indicate, on a 5-point Likert-type scale (1 = *very slightly or not at all* to 5 = *extremely*), the extent to which they generally experience emotions (e.g., “*Hostile*”). The PANAS is a well-established affective measure (Watson, Clark, & Tellegen, 1988). Factor analysis indicates that it assesses two global dimensions of affect: negative and positive. Both subscales of the PANAS have demonstrated good convergent and discriminant validity. Additionally, both the negative affect as well as the positive affect scales of the PANAS have demonstrated high levels of internal consistency (range of alpha coefficients: .83 to .90 and .85 to .93, respectively). A large body of literature supports the psychometric properties of the PANAS (see Watson, 2000). For the purposes of the present study, only the negative affectivity subscale (PANAS-NA) was used to assess the trait-like tendency to experience negative affect states.

The *Anxiety Sensitivity Index* (ASI; Reiss, Peterson, Gursky, & McNally, 1986) is a 16-item measure on which respondents indicate, on a 5-point Likert-type scale (0 = *very little* to 4 = *very much*), the degree to which they fear the potential negative consequences of anxiety-related symptoms and sensations. The ASI consists of one higher-order factor (ASI Total Score) and three lower-order factors: Physical, Psychological, and Social Concerns (Zinbarg, Barlow, & Brown, 1997). In the present investigation, as in past work (Zvolensky, Kotov, Antipova, & Schmidt, 2005), the total ASI score was used, as it represents the global AS factor and therefore reflects the different types of lower-order fears.

The *Kentucky Inventory of Mindfulness Skills* (KIMS) is a 39-item questionnaire on which respondents indicate, on a 5 point Likert-type scale (1 = *never or very rarely true* to 5 = *almost always or always true*), the general tendency to be mindful in daily life (Baer, Smith, & Allen, 2004). Factor analysis of the measure indicates that it has a hierarchical structure, with four first-order factors entitled Observing (e.g. “*I pay attention to how my emotions affect my thoughts and behavior*”), Describing (e.g. “*I’m good at finding the words to describe my feelings*”), Acting With Awareness (e.g. “*When I’m doing something, I’m only focused on what I’m doing, nothing else*”), and Accepting Without Judgment (e.g. “*I criticize myself for having irrational or inappropriate emotions*” - reverse scored). The KIMS appears to have good internal consistency, with alpha coefficients calculated from an undergraduate sample for Observing, Describing, Acting With Awareness, and Accepting Without Judgment of .91, .84, .83, and .87, respectively (Baer et al., 2004). In the present study, the Accepting Without Judgment subscale was utilized as an index of emotional acceptance.

Challenge measures—The *Diagnostic Sensations Questionnaire* (DSQ; Sanderson, Rapee, & Barlow, 1988, 1989) was used to assess DSM-IV panic attack symptoms immediately following the biological challenge. This measure is frequently employed in challenge work (Zvolensky, Lejuez, & Eifert, 1998). Ratings for the DSQ are made on a 9-point Likert type scale (0 = *not at all* to 8 = *very strongly felt*). The DSQ, specifically, lists DSM-IV panic symptoms and yields composite scores for a mean intensity level for cognitive (e.g., fear of going crazy) and physical (e.g., breathlessness or smothering sensations) symptoms.

The *Subjective Units of Distress Scale* (SUDS; Wolpe, 1958) was used to index self-reported anxiety. This Likert-type scale ranges from 0 (*no anxiety*) to 100 (*extreme anxiety*) in subjective ratings of anxiety. Participants completed these scales before the challenge procedure (as an index of baseline anxiety) and immediately after the challenge (as an index of maximal postchallenge anxiety). For the purposes of the present study, a difference score was computed between baseline and immediate post-challenge, indexing pre/post change in self-reported anxiety.

Avoidance of future challenge exposure/behavioral avoidance—In order to index avoidance post-challenge, participants’ willingness to participate in another CO₂ administration was evaluated by a paper-and-pencil questionnaire at the end of the recovery period. This item asked participants to rate their *level* of willingness to participate in another CO₂ administration study; it represented a measure of panic-relevant behavioral avoidance. Specifically, at the end of the recovery phase, participants were asked to indicate, on a 100-point Likert-style questionnaire, their interest in returning for another CO₂ investigation (0 = *no desire to participate*; 100 = *definite desire to participate*). This type of index has been utilized successfully in the past with biological challenge paradigms (Eifert & Heffner, 2003).

Materials and Apparatus

Carbon dioxide enriched air was stored in a 24-inch diameter hospital grade latex bag and delivered via 5-centimeter tubing to a positive-pressure C-pap mask worn by the participant. In addition to a one-way mirror, a video and audio monitoring system allowed the experimenter to observe all session events. A J&J Engineering I-330-C2 system was used to digitally record physiological data on-line at a sample rate of 1024 samples per second across all channels using J&J Engineering Physiolab Software. Two physiological variables were examined for the current study: heart rate and skin conductance. Both heart rate and skin conductance were obtained through the placement of electrodes on the wrists and fingers of each participant.

Procedure

Interested persons responding to advertisements who contacted the research team were given a detailed description of the study over the phone. After providing verbal consent, the SCID-NP was administered by a trained research assistant via telephone. Those meeting inclusionary criteria were scheduled to attend a single laboratory session. Upon arrival, participants completed a written informed consent, which indicated that the procedure involved a single 4-min 10% CO₂-enriched air presentation. Participants then completed the pre-experimental measures. Each participant was then introduced to the laboratory setting for the challenge procedure. During the session, participants sat alone in the 8-ft × 12-ft sound attenuated experimental room, which contained a computer, chair, desk, and intercom that allowed participants to communicate freely with the experimenter in the adjacent room. Participants were seated in front of a table, on which a binder with the experimental, paper-pencil self-report measures was placed. Once the electrodes were attached standardized instructions were provided:

“Following the (10 minute) adaptation period, we will start the experimental portion of the study which will last approximately 4 minutes. During this period you will receive several inhalations of CO₂-enriched air that may produce physical and mental sensations associated with bodily arousal. You may temporarily feel your heart racing, your palms might be sweaty, you might feel dizzy, and you might have some breathing problems.”

The study consisted of two phases. The first phase involved a 10-min baseline adaptation period during which participants sat quietly in the testing room breathing regular room air. Participants completed SUDs ratings at the beginning and end of the adaptation period. Phase two consisted of the automated delivery of one 4-min 10% CO₂-enriched air presentation. Participants completed a SUDs rating and the DSQ immediately after completing the 4-minute challenge exposure. Then, participants completed the avoidance of future challenge exposure measure. Participants remained in the experimental room for a 10-minute recovery period. Physiological data were gathered continuously across both phases. After the study, participants were debriefed and compensated \$20.

Results

Zero-Order Correlations among Theoretically-Relevant Variables

See Table 1 for a summary of zero-order correlations. Regarding the relation between the primary predictor variables and the criterion variables, Intolerance of Discomfort or Pain was, as expected, positively correlated with SUDS anxiety change ($r = .15, p < .05$), physical panic symptoms ($r = .16, p < .05$), cognitive panic symptoms ($r = .16, p < .05$), and negatively correlated with behavioral avoidance ($r = -.16, p < .05$; such that those with higher intolerance of discomfort report less willingness to participate in a future challenge). Avoidance of Physical Discomfort, on the other hand, was not significantly correlated with any of the criterion variables (all p 's $> .05$). Regarding the relations between the covariates and criterion variables, anxiety sensitivity was significantly correlated with all of the criterion variables: SUDS change score ($r = .16, p < .05$), physical panic symptoms ($r = .27, p < .01$), cognitive panic symptoms ($r = .36, p < .01$), and behavioral avoidance ($r = -.17, p < .05$; such that those with higher anxiety sensitivity reported less willingness to participate in a future challenge). On the other hand, negative affectivity was significantly positively associated only with cognitive panic symptoms ($r = .18, p = .01$) and the KIMS acceptance subscale was not significantly related to any of the criterion variables (all p 's $> .05$).

Hierarchical Regression Analyses

Criterion variables included (1) SUDS anxiety change score, (2) DSQ physical panic symptoms, (3) DSQ cognitive panic symptoms, and (4) behavioral avoidance. The main effects of ASI total score (ASI-T), negative affectivity (PANAS-NA), and the KIMS Accepting Without Judgment scale were entered simultaneously at step one of the model. The main effects of the two factors of the DIS (Intolerance of Discomfort or Pain and Avoidance of Physical Discomfort) were entered simultaneously at step two of the model. Please see Table 2 for a summary of the hierarchical regression analyses.¹

In terms of the DIS subscales predicting SUDS anxiety change, step one of the model accounted for 4% of the variance, and the ASI total score was the only significant predictor ($\beta = .21$; $sr^2 = .03$; $p < .01$). Partially as expected, the second step of the model accounted for an additional 2% of the variance, with only the Intolerance of Discomfort or Pain subscale of the DIS significantly contributing to the prediction of SUDS anxiety change above and beyond the variance accounted for by the main effects at step one ($\beta = .15$; $sr^2 = .02$; $p < .05$).

Regarding the prediction of physical panic symptoms, step one of the model accounted for 10% of the variance, and both the ASI total score ($\beta = .30$; $sr^2 = .07$; $p < .01$) and KIMS acceptance subscale ($\beta = .19$; $sr^2 = .03$; $p < .05$) were significant predictors. Partially as expected, step two of the model accounted for an additional 2% of the variance, with only the Intolerance of Discomfort or Pain subscale of the DIS significantly contributing to the prediction of DSQ physical panic symptoms above and beyond the variance accounted for by the main effects at step one ($\beta = .15$; $sr^2 = .02$; $p < .05$).

In terms of the DIS subscales predicting DSQ cognitive panic symptoms, step one of the model accounted for 14% of the variance, and the ASI total score was the only significant predictor ($\beta = .36$; $sr^2 = .11$; $p < .01$). Contrary to expectation, neither DIS subscale significantly contributed to the prediction of cognitive panic symptoms above and beyond the variance accounted for by the main effects at step one ($p > .05$).

Regarding the prediction of behavioral avoidance, step one of the model accounted for 5% of the variance, with the ASI total score as the only significant predictor ($\beta = -.21$; $sr^2 = .03$; $p < .01$). Partially as expected, step two of the model accounted for an additional 3% of the variance, and only the Intolerance of Discomfort or Pain subscale of the DIS significantly contributed to the prediction of one's interest in returning to another challenge procedure above and beyond the variance accounted for by the main effects at step one ($\beta = -.17$; $sr^2 = .03$; $p < .05$), such that those with greater intolerance of discomfort or pain report less willingness to participate in a future challenge.²

¹Regression equations also were completed for each dependent variable with the global score of the DIS entered at step 2 rather than the main effects of the 2 factors of the DIS. Initial zero-order correlations revealed the global score of the DIS to be significantly positively related to both the covariates of ASI ($r = .21$, $p < .01$) and negative affectivity ($r = .19$, $p < .01$) and the dependent variables of both cognitive ($r = .17$, $p < .05$) and physical ($r = .14$, $p < .05$) panic symptoms. The global score of the DIS was not related to SUDS change ($r = .12$, $p = .09$), behavioral avoidance ($r = -.10$, $p = .15$), or acceptance ($r = -.12$, $p = .08$). Results indicated that the global score of the DIS, above the variance accounted for by the covariates at step 1, was not associated with either SUDS change ($t = 1.62$; $p = .11$), physical panic symptoms ($t = 1.54$; $p = .13$), cognitive panic symptoms ($t = 1.35$; $p = .18$), or behavioral avoidance ($t = -1.06$; $p = .29$). These analyses are not reported in full in the manuscript because they were not part of the theoretical model being evaluated on an *a priori* basis.

²Two additional exploratory analyses were completed to determine if the Intolerance of Discomfort or Pain and Avoidance of Physical Discomfort subscales of the DIS were predictive of physiological change between pre- and post-challenge. The design of the hierarchical regression analyses was similar to that of the primary analyses, with the only difference being the dependent variables. The difference between the first minute of recovery and the last minute of baseline recordings for both heart rate and skin conductance were entered separately as criterion variables. Results indicated that neither Avoidance of Physical Discomfort nor Intolerance of Discomfort or Pain were predictive of either skin conductance ($t = .65$, $p = .51$ and $t = -.79$, $p = .43$; respectively) or heart rate change ($t = .29$, $p = .77$ and $t = -.13$, $p = .89$; respectively). These analyses are not reported in full in the manuscript because they were not part of the theoretical model being evaluated on an *a priori* basis.

Discussion

The present investigation examined the role of discomfort intolerance, as indexed by the Discomfort Intolerance Scale (Schmidt et al., 2006), in relation to panic-relevant symptoms elicited via a biological challenge. Overall, the study findings indicated small, although unique, relations between intolerance of discomfort or pain and vulnerability for panic symptoms.

Consistent with prediction, after accounting for variance explained by anxiety sensitivity, negative affectivity, and emotional acceptance, intolerance of discomfort or pain was incrementally predictive of change in level of anxious arousal, physical panic symptoms, and behavioral avoidance in response to the panic provocation challenge. No incremental effect was observed in relation to cognitive panic symptoms. The observed effects were consistently small in magnitude when judged from the zero-order or incremental level of analysis (see Tables 1 and 2). This pattern of findings is broadly consistent with theoretical models of discomfort intolerance in terms of panic vulnerability (Schmidt et al., 2007). It is noteworthy that incremental effects observed between the intolerance of discomfort or pain and the panic-relevant variables cannot be alternatively explained by shared variance between the two sub-dimensions of discomfort intolerance or between it and the anxiety sensitivity, negative affectivity, or emotional acceptance covariates. Thus, the current study findings suggest that there may be explanatory promise to the intolerance of discomfort or pain facet of the DIS in relation to certain types of panic-relevant symptoms. Lack of effects for cognitive aspects of panic responding may suggest intolerance of discomfort or pain is not ‘driving’ catastrophic thinking (e.g., “I am losing control”) in response to bodily perturbation, but rather, seems more applicable to perceived intensity of physical symptoms, anxiety focused on somatic sensations, and avoidance of panic-relevant stress in the future. Future work would benefit from replicating and extending the current findings using a field-based study that involved prospective monitoring of panic attacks and anticipatory anxiety about panic episodes.

In the present study, avoidance of physical discomfort DIS subdimension was not incrementally related to any of the panic-relevant dependent variables, nor was it correlated with these variables at the zero-order level. This finding is inconsistent with past work (Schmidt et al., 2006). It is possible that the lack of effects in the current study for the avoidance of physical discomfort dimension in terms of panic variables, in contrast to earlier investigations (Schmidt et al., 2006), may be at least partially due to the nature of the current sample (e.g., psychiatrically healthy) and possible resulting limited variability. Specifically, though the mean and standard deviation for the intolerance of discomfort or pain subscale is similar to mean levels observed in other clinical and non-clinical populations (Schmidt et al., 2006, 2007), the mean and standard deviation for the avoidance of physical discomfort subscale in the present study is well below that observed in studies of clinical populations (e.g. panic disordered; Schmidt et al., 2006). It also is important to observe that the current investigation examined the DIS sub-factors in the context of one another (simultaneously entered in the model) whereas past work had explored their predictive value separately from one another (Schmidt et al., 2006, 2007). Future work could usefully add to this line of inquiry by replicating the current findings and continuing to concurrently examine the DIS sub-factors in relation to panic psychopathology.

Although not the primary objective of the current investigation, it is noteworthy that DIS subscales were moderately correlated with one another (18% shared variance). At the zero-order level, the two DIS sub-factors also showed differential associations with negative affectivity, anxiety sensitivity, and emotional acceptance (see Table 1). Here, DIS avoidance was significantly related in the expected direction with each construct (range or r 's $-.18$ to $.23$), whereas DIS intolerance of pain and discomfort was not (range of r 's $-.01$ to $.11$). Such findings are noteworthy, in conjunction with the DIS sub-factor differential associations with

the dependent panic measures. Indeed, these data suggest that although related, these lower-order dimensions of discomfort intolerance also may be distinct in terms of their nomological relations with panic-related factors. This pattern of results highlights the potential complexity involved in the study of discomfort intolerance, its measurement and latent structure, and the early stage of this area of study. Future work is needed to continue to develop the construct and its measurement as well as to evaluate its nomological network. This work is to be particularly informative when it incorporates a multimethod approach in the evaluation of construct validity.

Several limitations of the study qualify the present findings. First, study of lower-order dimensions of a higher-order discomfort intolerance factor was limited by the psychometrically small number of items comprising the Discomfort Intolerance Scale (5 items in total). Consequently, ongoing efforts to conceptualize and measure discomfort intolerance that include additional items and thereby potentially more reliable measurement of each of these putative dimensions of discomfort intolerance may yield alternative findings in relation to panic vulnerability. Second, the homogeneity of the sample, in terms of race and ethnicity, limits the generalizability of the results. Future studies could be directed at the study of discomfort intolerance in relation to panic psychopathology among more diverse samples. Third, in regard to the measure of behavioral avoidance, the person's report of their desire to return for a future challenge may not be fully in line with their actual behavior, such that a participant may report that they would be willing to return, but may not actually follow through, and vice versa. It also is possible this measure of avoidance may tap boredom, frustration, or related factors rather than 'pure' fear-driven avoidance. Thus, future work should attempt to solidify this finding through a more rigorous methodology. Fourth, the present cross-sectional correlational design does not permit causal-oriented hypothesis testing. Although an attempt to strengthen confidence in the observed findings was achieved by controlling for theoretically-relevant factors, causal directions of the observed relations cannot be fully determined. Finally, we utilized the Accepting Without Judgment subscale of the KIMS as an index of emotional acceptance. This measurement tactic, although grounded in past empirical work (Baer et al., 2004), represents only one type of conceptualization of emotional acceptance. It may therefore be advisable for future work to examine alternative measurement approaches for emotional acceptance in efforts to further evaluate the unique explanatory power of discomfort intolerance in relation to panic vulnerability.

Overall, the present investigation adds uniquely to the extant empirical literature on discomfort intolerance and panic-relevant processes. Results suggest that although the two DIS sub-factors are related to one another, only the intolerance of discomfort and pain sub-factor is related to post-challenge intensity of panic attack symptoms, anxiety focused on bodily sensations, and willingness to participate in a future biological challenge study (behavioral avoidance) within the context of a CO₂ paradigm. Using this type of basic research to guide our understanding of clinically-relevant processes will continue to be an important task for translational research efforts focused on panic psychopathology.

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References

- Baer RA, Smith GT, Allen KB. Assessment of mindfulness by self-report: The Kentucky Inventory of Mindfulness Skills. *Assessment* 2004;11:191–203. [PubMed: 15358875]
- Barlow DH, Allen LB, Choate ML. Toward a unified treatment for emotional disorders. *Behavior Therapy* 2004;35:205–230.
- Eifert, GH.; Forsyth, JP. Acceptance and commitment therapy for anxiety disorders: A practitioner's treatment guide using mindfulness, acceptance, and values based behavior change strategies. Oakland, CA: New Harbinger; 2005.
- Eifert GH, Heffner M. The effects of acceptance versus control contexts on avoidance of panic-related symptoms. *Journal of Behavior Therapy and Experimental Psychiatry* 2003;34:293–312. [PubMed: 14972675]
- Feldner MT, Hekmat H, Zvolensky MJ, Vowles KE, Secrist Z, Leen-Feldner EW. The role of experiential avoidance in acute pain tolerance: A laboratory test. *Journal of Behavior Therapy and Experimental Psychiatry* 2006;37:146–158. [PubMed: 15882839]
- First, MB.; Spitzer, RL.; Gibbon, M.; Williams, JBW. Structured Clinical Interview for DSM-IV Axis I Disorders- Non-Patient Edition. New York: New York State Psychiatric Institute; 1995.
- Geisser ME, Robinson ME, Pickren WE. Differences in cognitive coping strategies among pain-sensitive and pain-tolerant individuals on the cold-pressor test. *Behavior Therapy* 1992;23:31–41.
- Gross JJ. The emerging field of emotion regulation. *Review of General Psychology* 1998;2:271–299.
- Hayes SC, Shenk C. Operationalizing mindfulness without unnecessary attachments. *Clinical Psychology: Science and Practice* 2004;11:249–254.
- Hayes, SC.; Strosahl, KD.; Wilson, KG. Acceptance and Commitment Therapy. Guilford; New York: 1999.
- Hayes SC, Wilson KW, Gifford EV, Follette VM, Strosahl K. Experiential avoidance and behavioral disorders: A functional dimensional approach to diagnosis and treatment. *Journal of Consulting and Clinical Psychology* 1996;64:1152–1168. [PubMed: 8991302]
- Linehan, M. Cognitive-Behavioral Treatment of Borderline Personality Disorder. New York: Guilford Press; 1993.
- McNally RJ. Anxiety sensitivity and panic disorder. *Biological Psychiatry* 2002;52:938–946. [PubMed: 12437935]
- Orsillo SM, Roemer L, Barlow DH. Integrating acceptance and mindfulness into existing cognitive-behavioral treatment for GAD: A case study. *Cognitive and Behavioral Practice* 2003;10:223–230.
- Ramel W, Goldin PR, Carmona PE, McQuaid JR. The effects of mindfulness meditation on cognitive processes and affect in patients with past depression. *Cognitive Therapy and Research* 2004;28(4): 433–455.
- Reiss S, Peterson RA, Gursky DM, McNally RJ. Anxiety sensitivity, anxiety frequency and the prediction of fearfulness. *Behaviour Research and Therapy* 1986;24:1–8. [PubMed: 3947307]
- Sanderson WC, Rapee RM, Barlow DH. Panic induction via inhalation of 5.5% CO-sub-2 enriched air: A single subject analysis of psychological and physiological effects. *Behaviour Research and Therapy* 1988;26:333– 335. [PubMed: 3145734]
- Sanderson WC, Rapee R, Barlow D. The influence of an illusion of control on panic attacks induced via inhalation of 5.5% CO2 enriched air. *Archives of General Psychiatry* 1989;46:157–162. [PubMed: 2492423]
- Schmidt NB, Lerew DR. Prospective evaluation of psychological risk factors as predictors of functional impairment during acute stress. *Journal of Occupational Rehabilitation* 1998;8:199–212.
- Schmidt NB, Richey JA, Cromer KR, Buckner JD. Discomfort intolerance: Evaluation of a potential risk factor for anxiety psychopathology. *Behavior Therapy* 2007;38:247–255. [PubMed: 17697850]
- Schmidt NB, Richey JA, Fitzpatrick KK. Discomfort Intolerance: Development of a construct and measure relevant to panic disorder. *Journal of Anxiety Disorders* 2006;20:263–280. [PubMed: 16564432]
- Simons JS, Gaher RM. The Distress Tolerance Scale: Development and validation of a self-report measure. *Motivation and Emotion* 2005;29:83–102.

- State of Vermont Department of Health. 2000. Retrieved September 3, 2002, from <http://www.healthyvermonters.info/>
- Watson, D. Mood and temperament. New York: Guilford Press; 2000.
- Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology* 1988;54:1063–1070. [PubMed: 3397865]
- Wolpe, J. Psychotherapy by reciprocal inhibition. Stanford, CA: Stanford University Press; 1958.
- Zinbarg R, Barlow DH, Brown T. The hierarchical structure and general factor saturation of the Anxiety Sensitivity Index: Evidence and implications. *Psychological Assessment* 1997;9:277–284.
- Zvolensky MJ, Eifert GH. A review of psychological factors/processes affecting anxious responding during voluntary hyperventilation and inhalations of carbon dioxide-enriched air. *Clinical Psychology Review* 2000;21:375–400. [PubMed: 11288606]
- Zvolensky MJ, Kotov R, Antipova AV, Schmidt NB. Diathesis stress model for panic-related distress: A test in a Russian epidemiological sample. *Behaviour Research & Therapy* 2005;43:521–532. [PubMed: 15701361]
- Zvolensky MJ, Leen-Feldner EW, Feldner MT, Bonn-Miller MO, Lejuez CW, Kahler CW, Stuart G. Emotional responding to biological challenge as a function of panic disorder and smoking. *Journal of Anxiety Disorders* 2004;18:19–32. [PubMed: 14725866]
- Zvolensky MJ, Lejuez CW, Eifert GH. The role of control in anxious responding: An experimental test using repeated administrations of 20%CO₂-enriched air. *Behavior Therapy* 1998;29:193–209.
- Zvolensky MJ, Otto MW. Affective intolerance, sensitivity, and processing: Advances in clinical science. *Behavior Therapy* 2007;38:228–233.

Table 1
Descriptive Data and Zero-Order Relations among Theoretically-Relevant Variables

Variable Name	1	2	3	4	5	6	7	8	9	M (SD)
1. Anxiety Sensitivity	-	.37**	-.38**	.11	.23**	.16*	.27**	.36**	-.17*	15.92 (7.83)
2. Negative Affectivity	-	-	-.31**	.10	.21**	.01	.13	.18**	-.05	17.27 (4.72)
3. KIMS – Accept	-	-	-	-.01	-.18**	.05	.04	-.09	-.06	33.63 (6.86)
4. DIS - Intolerance	-	-	-	-	.43**	.15*	.16*	.16*	-.16*	4.13 (2.85)
5. DIS - Avoidance	-	-	-	-	-	.05	.08	.12	-.02	7.68 (3.29)
6. SUDS Change	-	-	-	-	-	-	.50**	.52**	-.22**	36.59 (25.98)
7. Physical Panic	-	-	-	-	-	-	-	.67**	-.32**	41.75 (19.18)
8. Cognitive Panic	-	-	-	-	-	-	-	-	-.29**	7.90 (6.85)
9. Behavioral Avoidance	-	-	-	-	-	-	-	-	-	60.99 (31.91)

* p < .05,

** p < .01;

¹ Anxiety Sensitivity Index – Total Score; ²Negative Affectivity Subscale, Positive Affect Negative Affect Scale; ³Accept Without Judgment Subscale – Kentucky Inventory of Mindfulness Skills; ⁴Intolerance of Discomfort or Pain Subscale -Discomfort Tolerance Scale; ⁵ Avoidance of Physical Discomfort Subscale - Discomfort Tolerance Scale; ⁶Subjective Units of Distress – Pre-Challenge/Post-Challenge Change Score; ⁷Physical Symptoms Scale – Diagnostic Sensations Questionnaire; ⁸Cognitive Symptoms Scale – Diagnostic Sensations Questionnaire; ⁹Behavioral Avoidance – Willingness to Participate.

Table 2

Discomfort Intolerance Predicts Anxious Responding

	ΔR^2	t (each predictor)	β	sr^2	p
Criterion Variable: SUDS Change⁶					
Step 1	.04				
Anxiety Sensitivity ¹		2.67	.21	.03	< .05
Negative Affectivity ²		-.38	-.03	.00	< .01
KIMS – Accept ³		1.71	.13	.01	ns
Step 2	.02				
DIS – Intolerance ⁴		1.99	.15	.02	ns
DIS – Avoidance ⁵		-.10	-.01	.00	< .05
Criterion Variable: Physical Panic⁷					
Step 1	.10				
Anxiety Sensitivity ¹		3.92	.30	.07	< .01
Negative Affectivity ²		1.27	.09	.01	< .01
KIMS – Accept ³		2.52	.19	.03	ns
Step 2	.02				
DIS – Intolerance ⁴		2.04	.15	.02	< .05
DIS – Avoidance ⁵		-.24	-.02	.00	ns
Criterion Variable: Cognitive Panic⁸					
Step 1	.14				
Anxiety Sensitivity ¹		4.87	.36	.11	< .01
Negative Affectivity ²		.93	.07	.00	< .01
KIMS – Accept ³		1.10	.08	.01	ns
Step 2	.01				
DIS – Intolerance ⁴		1.49	.11	.01	ns
DIS – Avoidance ⁵		.07	.01	.00	ns
Criterion Variable: Behavioral Avoidance⁹					
Step 1	.05				
Anxiety Sensitivity ¹		-2.63	-.21	.03	< .05
					< .01

	AR ²	t (each predictor)	β	sr ²	p
Negative Affectivity ²		-.55	-.04	.00	ns
KIMS – Accept ³		-1.85	-.14	.02	ns
Step 2	.03				ns
DIS – Intolerance ⁴		-2.28	-.17	.03	< .05
DIS – Avoidance ⁵		1.01	.08	.01	ns

Note: β = standardized beta weight;

sr² = Squared semi-partial correlation;

¹ Anxiety Sensitivity Index – Total Score;

² Negative Affectivity Subscale, Positive Affect Negative Affect Scale;

³ Accept Without Judgment Subscale – Kentucky Inventory of Mindfulness Skills;

⁴ Intolerance of Discomfort or Pain Subscale - Discomfort Tolerance Scale;

⁵ Avoidance of Physical Discomfort Subscale - Discomfort Tolerance Scale;

⁶ Subjective Units of Distress – Pre-Challenge/Post-Challenge Change Score;

⁷ Physical Symptoms Scale – Diagnostic Sensations Questionnaire;

⁸ Cognitive Symptoms Scale – Diagnostic Sensations Questionnaire;

⁹ Behavioral Avoidance – Willingness to Participate.