Research paper

Fear reactivity to cognitive dyscontrol via novel head-mounted display perceptual illusion exercises

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ARTICLE INFO

Keywords:
Suicide
Post-traumatic stress disorder
Anxiety sensitivity
Comorbidity

ABSTRACT

Background: Anxiety sensitivity cognitive concerns (ASCC), refer to fears of mental catastrophe or losing control over mental processes. Recent findings show that ASCC are related to suicide risk, mood disorders and trauma-related disorders. Using controlled experimental psychopathology paradigms could be one heretofore unutilized method of increasing understanding of ASCC. Our goal was to test fear reactivity to four head-mounted display perceptual illusion challenges designed to bring on feelings of cognitive dyscontrol (i.e., derealization, depersonalization) in a group of high and low anxiety sensitivity cognitive concerns participants.

Methods: Participants (N = 49) with Anxiety Sensitivity Index-3 cognitive scores at least 1.5 SD above or below the mean completed four cognitive dyscontrol challenges utilizing head-mounted display technology.

Results: Results showed all four challenges successfully elicited high cognitive anxiety symptoms. Consistent with other laboratory challenge studies, high versus low ASCC participants reported comparable cognitive symptoms but reported significantly greater fear.

Limitations: This was an initial proof of concept study designed to examine fear reactivity to cognitive dyscontrol challenges. Therefore, no control exercises were evaluated.

Conclusions: The finding that fear reactivity to the laboratory challenges can potentially serve as a viable behavioral correlate of ASCC provides a potentially useful exposure exercise for clients experiencing high levels of ASCC. Given the association between ASCC and severe psychopathology, with further investigation and refinement, such exposure exercises could be integrated into cognitive-behavioral treatments.

1. Introduction

Anxiety sensitivity (AS), which is defined as a fear of anxiety related sensations, is among the most well researched risk factors in the anxiety psychopathology literature. AS is composed of three lower order factors: physical concerns, cognitive concerns, and social concerns (Reiss et al., 1986). The vast majority of prior AS research has focused on AS physical concerns (e.g., “when my heart races I worry that I’m going to have a heart attack”), perhaps because the original Anxiety Sensitivity Index featured twice as many physical items as cognitive or social items. The creation of the Anxiety Sensitivity Index – 3 (ASI-3; Taylor et al., 2007) has sparked more interest in the cognitive and social concerns facets of AS. Surprisingly, recent findings have suggested that AS cognitive concerns (ASCC) are more related to mood and trauma disorders than anxiety disorders (Olthuis et al., 2013). Consistent with this finding, a growing body of work has found that ASCC are associated with suicide risk and reducing ASCC leads to declines in suicidal ideation (Capron et al., 2012c; Schmidt et al., 2014).

Anxiety sensitivity cognitive concerns (ASCC) refer to fears of mental catastrophe or losing control over mental processes. ASCC are triggered by depersonalization/derealization experiences, racing thoughts, and one’s mind “going blank” (Taylor et al., 2007). Several studies have found that ASCC is associated with suicidal ideation or suicide attempt history in samples of military cadets (Capron et al., 2012b), clinical outpatients (Capron et al., 2012c; Schmidt et al., 2001), cigarette smokers (Capron et al., 2012a), and individuals with HIV (Capron et al., 2012d). ASCC have also been found to interact with depression to predict suicide risk in clinical outpatients (Capron et al., 2013), young adults with elevated suicidality (Capron et al., 2014a, 2014b), adolescents (Capron et al., 2015), community samples (Oglesby et al., 2015), and male residential substance users (Capron et al., 2016).

These findings have led to the proposal of a depression distress amplification model (DDAM; Capron et al., 2013), whereby ASCC acts as an amplifier of suicide risk via increased cognitive depression symptoms (and increasing distress related to these increasingly severe symptoms). Such a model is potentially consistent with a risk factor that

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http://dx.doi.org/10.1016/j.jad.2017.03.068
Received 13 September 2016; Received in revised form 3 February 2017; Accepted 28 March 2017
Available online 07 April 2017
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would transition individuals from suicidal ideation to suicide attempt. Additional support for the DDAM can be seen in reports from psychiatric emergency rooms where individuals checking in with severe suicidal ideation/recurrent suicide attempt report catastrophic cognitive distress (e.g., “I feel like I’m losing my mind”; Katz et al., 2011), as well as empirical work demonstrating the relationship between ASCC and suicidality is mediated by increases in agitation and insomnia (Rogers et al., 2016), both established risks for suicide attempts (Bernert and Nadorff, 2015). However, other studies have found that this relationship is only significant via cognitive symptoms of depression (Norr et al., 2016). Thus, using controlled experimental psychopathology paradigms could be a heretofore unutilized method of elucidating the mechanisms through which ASCC confers risk for suicide.

Laboratory-based challenges have been utilized in experimental psychopathology work to examine how individuals react to novel stressors in a controlled setting (McNally and Eke, 1996). For example, biological challenges often induce physical sensations that approximate those present during panic attacks (e.g., heart palpitations, dizziness, shortness of breath) via techniques such as voluntary hyperventilation or inhalation of carbon dioxide enriched air (Zvolensky et al., 2001). Studies have shown that AS is a significant predictor of fear reactivity to challenge paradigms (Zinberg et al., 2001; Zvolensky et al., 2002), and that fear reactivity to laboratory challenges and AS are unique and interactive predictors of spontaneous panic (Schmidt et al., 2007), which promotes the utility of these paradigms in studying AS relevant clinical phenomena.

The vast majority of laboratory challenge work has focused on CO₂ inhalation or hyperventilation exercises that produce symptoms relevant to ASCC (i.e., derealization) but simultaneously produce many prominent physical sensations (e.g., tachycardia, trouble breathing, chest pain/tightness). Previous work has shown specificity in the perception of internal bodily sensations (Schmidt, 1999). Individuals with high anxiety sensitivity show greater vigilance to sensations corresponding with specific symptom domains (e.g., physical, cognitive, social). Prior studies indicate high levels of specificity for specific domains and are predictive of increased symptom endorsement for the corresponding sensations (Schmidt, 1999; Schmidt et al., 2002). Given the increasing recognition of ASCC as a correlate of psychopathology, it follows that greater evaluation of ASCC specific laboratory challenges, without the confounding effects of related physical sensations, is warranted.

One target for ASCC specific challenges, with minimal physical symptoms, are exercises that evoke feelings of dissociative symptoms (i.e., derealization and depersonalization). An episode of depersonalization or derealization is characterized by the experience of unreality with regard to the self or surroundings, respectively (APA, 2013). Although depersonalization/derealization symptoms occur across many disorders, one diagnosis that is particularly affected is the dissociative subtype of PTSD, now recognized in the DSM-5 (APA, 2013). Previous studies have found that approximately 15–30% of individuals with PTSD experience dissociative symptoms and the available evidence suggests this subtype has differential responses to exposure therapy compared to individuals with non-dissociative PTSD (Lanius et al., 2012; Steuwe et al., 2012; Wolf et al., 2012). Exercises such as staring at a dot or wall (derealization) and staring at a mirror (depersonalization) have been used by clinicians and researchers to evoke these symptoms. However, a number of anxiety researchers have remarked on the difficulty of evoking depersonalization/derealization episodes or weak levels of depersonalization/derealization sensations when using mirror/dot/wall staring ( Antony et al., 2006) and others have noted they are ineffective for many patients (Lickel et al., 2008). Given early evidence that dissociative symptoms result in more severe impairment, new interventions to target these symptoms that are more potent and reliable than mirror/dot/wall staring are needed (Stein et al., 2013).

To our knowledge, only two studies have attempted to improve on mirror/dot/wall staring challenges by testing fear reactions to other depersonalization/derealization challenges. In the first study, overall AS was predictive of fear reactivity to the Digital Audio Visual Integration Device (DAVID) dissociation program (wearing special glasses and seeing flashing LED lights and hearing binaural beats for 12 min) in 101 undergraduates (Leonard et al., 2000). However, the relationship between AS cognitive concerns and fear reactivity was not directly examined. In the second study, Lickel et al. (2008) tested 11 tasks designed to evoke depersonalization or derealization in a small sample of high AS undergraduates. They found four exercises that significantly predicted depersonalization greater than dot staring (i.e., 1 min hyperventilation, 5 min hyperventilation, 3 min of hyperventilation while staring at a spiral, and 3 min of hyperventilation while being in a dark room with a strobe light) and four exercises that predicted derealization significantly greater than dot/mirror staring (i.e., 5 min hyperventilation, 3 min of hyperventilation while staring at a spiral, 3 min of standing in a dark room with a strobe light, 3 min of hyperventilation while being in a dark room with a strobe light). However, this study also did not report specifically on ASCC or fear reactivity. It is also noteworthy that hyperventilation is associated with significant activation of AS physical concerns (Schmidt, 1999). Only one non-hyperventilation task (i.e., standing in a dark room with a strobe light for 3 min) produced significantly greater derealization than dot/mirror staring and no non-hyperventilation tasks produced significantly greater derealization than dot staring. Finally, although these two studies found improvements in the induction of derealization symptoms, (non-hyperventilation) improvements to depersonalization challenges have not been found.

Recent perceptual illusion exercises, using head-mounted display (HMD) technology, appear to create sensations of depersonalization (Petkova and Ehrsson, 2008). This study sought to elicit an out-of-body experience among healthy individuals through tasks designed to evoke ownership of a body other than their own. To accomplish this, Petkova and Ehrsson used an HMD connected to an external camera that showed participants a live feed of specific tasks from different visual perspectives. The altered visual perspective was then paired with simultaneous tactile stimulation to create a multisensory manipulation strong enough to trigger a body-swapping illusion [i.e., that another person’s body or an artificial body (i.e., a mannequin) was their own]. After the tasks, participants reported depersonalization through the sensation of body-ownership over the artificial and real bodies. Participant self-reports were corroborated by greater defensive reactivity in response to physical threat to the simulated body compared to physical threat to the participant’s actual body (Petkova and Ehrsson, 2008). Thus, these techniques appear to provide a promising potential methodology to invoke depersonalization, which could lead to the development of new laboratory challenge tasks for ASCC.

The aim of the present study was to create and evaluate laboratory challenge tasks relevant to ASCC. Two tasks modeled from the Petkova and Ehrsson (2008) paradigm and two novel tasks were tested. Based on the extant ASCC literature, we hypothesized that each task would yield increased cognitive sensations (ADJ-C) relative to baseline. We also examined whether the high ASCC group would show higher fear (subjective units of distress; SUDS) than the low ASCC group in the context of cognitive symptom induction.

2. Method

2.1. Participants

Participants (N = 49) with ASI-3 cognitive scores at least 1.5 SD above or below the mean were recruited through the psychology department participant pool and were provided class credit for their participation. Demographic characteristics for the low and high anxiety sensitivity cognitive concerns (ASCC) groups are included in Table 1. The study was approved by the university’s Institutional Review Board.
Table 1
Descriptive statistics for baseline measures by ASI-3 cognitive group.

|                        | High (n = 22) | Low (n = 27) | t
|------------------------|--------------|--------------|---
|                        | Mean | SD  | Mean | SD  |    |
| ASI-3 Cognitive        | 13.18 | 4.34 | .00  | .00  | -7.25*** |
| Age                    | 19.13 | 1.44 | 18.82 | 1.99 | -61 |
| Sex                    | Percentage | Percentage | $\chi^2$ | .02 |    |
| Male                   | 28%  | 33%  |       |      |    |
| Female                 | 72%  | 66%  |       |      |    |
| Race                   | White | 95%  | 89%  |      |    |
|                        | Female | 72%  | 66%  |      |    |
| Asian American         | 5%   | 11%  |       |      |    |

Note. ASI-3 = Anxiety Sensitivity Index-3.
*** p < .01.

2.2. Self-report measures

2.2.1. Acute dissociation inventory – cognitive (ADI-C)

The ADI measures experiences of dissociation during lab-based biological challenges (Leonard et al., 1999, 2000). To create a measure more amenable to repeated assessments we created a shortened inventory focused on the cognitive symptoms of dissociation (ADI-C). Seven items from the original ADI that the authors determined to best capture cognitive experiences were selected (See Table 2). Internal consistency of this measure was good at baseline (Cronbach’s $\alpha$ = .91), and excellent for the mannequin (Cronbach’s $\alpha$ = .92). Administration of the three AS subfactors: cognitive, physical, and social concerns. The current study used the ADI-C estimated marginal means for each task by ASI-3 cognitive group.

Table 2
ADI-C estimated marginal means for each task by ASI-3 cognitive group.

|                        | High (n = 22) | Low (n = 27) | SE
|------------------------|--------------|--------------|---
| Mannequin              | 82.68 | 19.71 | 77.10 | 15.92 |
| Handshake              | 151.04 | 28.28 | 113.04 | 22.84 |
| Opposite directions    | 125.19 | 26.21 | 74.32 | 21.17 |
| Rotation               | 207.06 | 35.52 | 156.78 | 28.68 |

Note. ASI-3 = Anxiety Sensitivity Index-3.

2.3. Description of perceptual illusion laboratory challenges

2.3.1. Mannequin

Mannequin was very similar to the mannequin perceptual illusion exercise created by Petkova and Ehrsson (2008) designed to elicit the feeling of swapping bodies with a mannequin. The main difference being we used a mannequin with gender neutral clothing (t-shirt, blue jeans) versus a bare mannequin. We used a mannequin, rather than another person’s body, to exclude mismatches between small involuntary movements (e.g., breathing). Participants were told “In this task you will be wearing a virtual reality headset that is connected to a camera worn by this mannequin. I will be using this brush to simultaneously stroke your abdomen as well as the abdomen of the mannequin.” The experimenter stroked the participant’s abdomen with the brush while simultaneously brushing the mannequin’s abdomen for 2 min. This challenge has been shown to successfully create the illusion that participants have switched bodies with the mannequin (Petkova and Ehrsson, 2008).

2.3.2. Handshake

This task was identical to the handshake perceptual illusion exercise created by Petkova and Ehrsson (2008) designed to elicit the feeling of shaking hands with one’s self. The experimenter held a camera (connected to the head mounted display) in such a way that they presented the viewpoint of the experimenter. The participants stood directly opposite the experimenter, wearing the HMD, which was connected to the camera on the experimenter’s head. Thus, the participants were facing the camera. The participants were asked to stretch out their right arm and take hold of the experimenter’s right hand, as if to shake it. This set-up allowed the participants to see their physical bodies from the shoulders to slightly above the knees. Hence, they were able to clearly recognize themselves and distinguish between their own arm and the arm of the experimenter. During the task, the participant and the experimenter repeatedly squeeze each other’s hands, in a synchronous manner, for 2 min. This challenge has been shown to successfully create the illusion that participant is shaking hands with him/herself (Petkova and Ehrsson, 2008).

2.3.3. Opposite directions

This task was created by the experimenters to create sensations of cognitive dyscontrol. The experimenter stood next to the participant with a camera (connected to the HMD) on a tripod (to provide smooth panning). See Fig. 1 for participant and experimenter positioning. The camera was positioned to mimic the participant’s natural field of vision. Participants were told “During this task I will be instructing you to turn your head in the following directions: right, left, up and down. I will also say “center” which means look straight ahead. Move your head in a slow, fluid motion. I will count out loud to four so try to make each motion last 4 s.” As the participant turned their head, the experimenter turned the tripod with the camera slowly in the opposite direction in a synchronous manner. The task was repeated for 2 min. The participant experiences a disconnect between their motor movements in one
direction and their sight of the room moving at equal speed in the opposite direction.

2.3.4. Rotation

This task was created by the experimenters to create sensations of depersonalization (i.e., out-of-body-experience). The experimenter positioned the camera (connected to the HMD) on the tripod 4 feet from the participant (See Fig. 2). The camera was positioned to capture the participant from the neck down, so as to see themselves spin from an “out of body” perspective. Participants were then given the following instructions: “During this task, please spin very, very slowly in a circle. To prevent you from tripping over the head’s cord, I will tell you when to start turning in the opposite direction. Please continue until I tell you to stop. Please spin slowly enough that you do not become dizzy”. Participants spun slowly for 2 min. This task created a disconnect between the expected first-person view one has while turning slowly and the “third-person” or “out of body” view they had during the task.

2.4. Procedure

Participants were invited for the experiment appointment via the psychology department’s secure research participant registration website. Upon entering the lab, participants provided informed consent and then completed baseline questionnaires. Participants then completed the four tasks in a small private experiment room in the order presented above. The decision to not counterbalance tasks was based on logistical issues. The tasks themselves involved precision movements by the experimenters to maintain the perceptual illusions and extensive rearrangement/recalibration of equipment. Therefore, the decision was made to perform the tasks in the order that would be most feasible for the experimenter and lab space. Participants removed the HMD and completed the ADI-C after each task. They were explicitly instructed to only answer based on their feelings during the preceding task. This break between challenges without wearing the HMD allowed participants to return to baseline levels of dissociation before starting the next task. After all four tasks were completed, participants then completed a small battery of post-experiment measures, were thanked for their time and given course credit.

3. Results

3.1. Descriptive statistics

Baseline descriptive data are included in Table 1. Results suggest that we were able to effectively recruit both a high ASCC group and a low ASCC group that were significantly different on ASCC. Demographic variables were similar between the two groups. Consistent with the undergraduate psychology majors at this university, the majority of participants were young females. These sample characteristics are consistent with other studies who have specifically recruited high AS samples (Clerkin et al., 2015; Keough and Schmidt, 2012).

3.2. Primary analyses

Four paired samples t-tests were conducted to evaluate the impact of each laboratory challenge on ADI-C. For all four laboratory challenges, there was a statistically significant pre to post challenge increase in ADI-C: 1) Mannequin \( t(48) = 6.64, p < .001 \) (two-tailed), \( \eta^2 = .44 \), 2) Handshake \( t(48) = 8.14, p < .001 \) (two-tailed), \( \eta^2 = .55 \), 3) Opposite Directions \( t(48) = 6.50, p < .001 \) (two-tailed), \( \eta^2 = .43 \), 4) Rotation \( t(49) = 9.33, p < .001 \) (two-tailed), \( \eta^2 = .61 \). All effects were large according to the guidelines proposed by Cohen (1988).

To evaluate whether the tasks created similar levels of cognitive sensations between the high and low ASCC groups, equivalence analyses were performed. As suggested by Rogers et al. (1993), an equivalence interval of ± 10% was utilized. We used ADI-C estimated marginal means, covarying for baseline ADI-C. Using a 90% confidence intervals of ADI-C estimated marginal means, the ranges for the high ASCC group are contained within the equivalence interval for all four tasks (i.e., mannequin, handshake, opposite directions, rotation) and therefore it can be concluded they were equivalently affected by the HMD tasks (See Fig. 3 and Table 3).

Four separate analysis of covariance (ANCOVA) analyses were performed to examine differences in fear reaction (SUDS) to each of the four tasks. Baseline SUDS was included as a covariate in all analyses. The results showed that the high ASCC group had significantly higher fear reaction to the Mannequin - \( F(2, 49) = 5.04, p = .03, \eta^2 = .10 \); Handshake - \( F(2, 49) = 5.72, p = .02, \eta^2 = .11 \); Opposite Directions - \( F(2, 49) = 13.79, p < .01, \eta^2 = .23 \); and Rotation - \( F(2, 49) = 9.53, p < .01, \eta^2 = .17 \), tasks (See Fig. 4).

4. Discussion

All four laboratory challenges were successful at eliciting high cognitive anxiety symptoms including dissociation and depersonalization. Consistent with other laboratory challenge studies, high AS and
low AS participants report comparable symptoms but there is a difference in fear reactivity (Zvolensky et al., 2001). Lastly, based on the effect sizes it appears that the two novel challenges created for this study (e.g., opposite directions and rotation) were more potent at eliciting ASCC than two tasks designed to create “bodyswapping” illusions we took from previous literature.

Greater fear reactivity in the high ASCC group is consistent with previous work that found a similar relationship between overall AS and fear reactivity to the dissociation challenge (Leonard et al., 2000). However, the Leonard et al. (2000) study did not measure specific AS subfactors so the role of ASCC in that study is not known. These results are also consistent with findings that 3 min of being in a dark room with a strobe light can induce significantly symptoms of derealization in high AS undergraduates (Lickel et al., 2008). It is difficult to compare the potency of our challenges to these previous tasks due to different assessments and task durations. However, it should be noted that the challenges in the current study were completed for only 2 min, whereas the strobe light challenge in Lickel et al. (2008) was 3 min and the dissociation challenge in Leonard et al. (2000) was 12 min.

The current study has a number of clinical implications. First, the finding that fear reactivity to the laboratory challenges can potentially serve as a viable behavioral correlate of ASCC provides a potentially useful exposure for clients experiencing high levels of ASCC, such as individuals with the dissociative subtype of PTSD. Protocols that induce depersonalization and derealization symptoms have been used in exposure paradigms to decrease the experience of these experiences (Weiner and McKay, 2012). Therefore, it is likely that repeated exposure to such paradigms (including the one utilized in the current study) could result in decreases in ASCC. One study suggests that individuals with the dissociative subtype of PTSD responded better to treatment that included additional components along with traditional prolonged exposure (Cloitre et al., 2012). Adding perceptual illusion exercises to traditional exposure treatments may be one avenue to make further treatment gains with individuals suffering from dissociative symptoms in the context of PTSD. Another important clinical implication is related to the association between ASCC and suicide (Capron et al., 2014b; Oglesby et al., 2015; Schmidt et al., 2001). In fact, depersonalization (a trigger for ASCC) has been hypothesized as a contributor to suicidal behavior for more than a half century (Waltzer, 1968). Therefore, novel interventions that may reduce suicide risk have the potential for great impact.

It is important to note several limitations in the current study. First, this was designed as an initial proof of concept study. There was no counterbalancing of exercises due to logistical and technical issues so this potentially compromises our ability to compare the relative potency of the four exercises to each other. Another limitation with the current design was there were no control exercises designed to have no effect on ASCC (e.g., relaxed breathing). Therefore, it cannot be ruled out that participants in high ASCC group may just be more reactive to self-report assessments than individuals in the low ASCC group. However, this seems highly unlikely as individuals in the high and low AS groups were not significantly different on an eight item measure of well-being included in the assessment battery. Future work in this area should include both control exercises and also comparison exercises (e.g., mirror staring, strobe light) to test the relative effects of these new laboratory challenges.

Potent and reliable laboratory challenges for depersonalization/derealization have eluded the field for decades. Most anxiety treatment manuals still recommend mirror/dot/wall staring despite their lack of efficacy for most patients. The burgeoning research showing ASCC plays a role in mood, trauma, and suicide psychopathology highlights the need for more advanced investigation of this construct. Given the vast literature that has used laboratory challenges (e.g., CO₂ voluntary hyperventilation) for the controlled study of anxiety pathology, it would be prudent to further refine and strengthen ASCC relevant challenges.

References


Fig. 4. Differences in maximum fear reported after each task between high ASCC and low ASCC groups. SUDS = Subjective units of distress.


