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Fear reactivity to head-mounted display perceptual illusion challenges is associated with suicidality

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ABSTRACT

Suicide remains a public health concern with suicide rates showing a consistent increase over the last 20 years. Recent studies have found a relationship between anxiety sensitivity (i.e., the fear of anxiety related symptoms) and suicidality. Specifically, a relationship has been found between anxiety sensitivity cognitive concerns (ASCC) and suicidality. The knowledge around this relationship, however, has relied mostly on self-report measures. This study seeks to expand on the current literature by exploring the association between ASCC and suicidality, through the use of head-mounted display perceptual illusion challenges (e.g., using tactile sensations and mannequins to create illusions that the participant has switched bodies). A head-mounted display was used to elicit symptoms (e.g., depersonalization, derealization) related to ASCC in a sample of undergraduate students ($N = 54$). Suicidality and depression were measured by the Inventory of Depression and Anxiety Symptoms-2 (IDAS-II), anxiety sensitivity cognitive concerns by the Anxiety Sensitivity Index-3 (ASI-3), and distress by the Subjective Units of Distress Scale (SUDS). Findings indicated that suicidality was associated with self-reported ASCC as well as the fear generated from the challenges. Furthermore, our results found that challenge-induced fear predicted suicidality scores above and beyond the traditional self-report measures of ASCC. The small sample size and low suicide risk of the current sample limits generalizations to more severe populations.

1. Introduction

Suicide remains a major public health concern, as the tenth leading cause of death in the United States (US; CDC, 2015). Approximately 113 people die by suicide each day in the US (CDC, 2015). Despite concerted multidisciplinary efforts towards suicide prevention, suicide rates have been increasing over the last twenty years (Curtin et al., 2016). One of the difficulties in studying suicide and suicide-related phenomena is that most assessments have been limited to recall-based self-report measurement (e.g., Beck Scale for Suicide Ideation; Beck et al., 1979) in which participants are asked to recall their experience of and reaction to symptoms that have occurred in the past. Though this method is useful in many ways, it relies on an individual's memory which could be biased or inaccurate. Current suicide research relies heavily on recall-based self-report measures to identify individuals at risk for suicide (Nock et al., 2010). Such measures, however, are limited in their ability to accurately gather information as many individuals have motivations to conceal suicide-related thoughts and behaviors (Busch et al., 2003) and are often unaware of their own mental processes (Wilson, 2009).

Developing alternatives to existing recall-based self-report measures could allow researchers to better understand the nature of suicide more generally. One example of these alternatives are laboratory-based challenges from the anxiety literature, such as hyperventilation (Holloway and McNally, 1987), high doses of caffeine (Telch et al., 1996) or inhalations of high concentrations of carbon dioxide (Schmidt, 1999). Such challenges, in comparison to recall-based self-report, eliminate memory bias and can provide a more immediate evaluation of relevant fears. In this study, we explore the use of perceptual illusion challenges to better understand anxiety and suicidal ideation.

Several studies have identified a relationship between anxiety sensitivity (AS) and suicide (Capron et al., 2012b, 2012c; Norr et al., 2016b; Oglesby et al., 2015; Osman et al., 2010; Valentiner et al., 2002). AS, refers to a fear of fear, and is divided into three dimensions: fears of physical, social, and cognitive aspects of anxiety (Reiss et al., 1986; Taylor et al., 2007). AS physical concerns refer to a fear of physical catastrophe, such as the fear that an elevated heart rate will

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cause a heart attack. AS social concerns refer to a fear of negative social repercussions related to anxiety (e.g., that someone will notice anxiety symptoms). AS cognitive concerns (ASCC) refer to fears of mental ruin, such as losing control over one's cognitive abilities.

Of the AS subcomponents, ASCC appears to be the facet accounting for the relationship between AS and suicidal ideation (Capron et al., 2012a, 2012c; Norr et al., 2016b; Oglesby et al., 2015). It could be that individuals with fears such as "going crazy" or losing control during stressful situations may find solace in the thought of permanently terminating these fears through death. Whereas the exact thoughts and desires occurring during suicidal crises are unknown, several studies support the association between ASCC and suicide-related thoughts and behaviors. For example, Oglesby et al. (2015) found that ASCC successfully differentiated between individuals with high and low risk for suicide whereas AS physical concerns and AS social concerns failed to make such cross-sectional predictions. Moreover, Capron et al. (2012b) found that elevations in ASCC prospectively predicted greater suicidal ideation among military cadets undergoing basic training ($N = 1081$). Similarly, other studies have found that reducing ASCC led to decreased suicidal ideation (Schmidt et al., 2014; Schmidt et al., 2017). Thus, ASCC meets established criteria as a *causal risk factor* for suicidal ideation because elevated ASCC is correlated with suicidal ideation (e.g., Capron et al., 2012a, 2013a), precedes suicidal ideation (Capron et al., 2012a), and reductions in ASCC reduce suicidal ideation (Schmidt et al., 2014,2017). Given the well-documented link between ASCC and suicide-related thoughts and behaviors, and limitations to recall-based self-report methods, alternative or complementary challenge-based measures of ASCC could be beneficial in efforts to better understand suicide and suicidal crises.

Despite the clear link between ASCC and suicide, this literature has relied exclusively on recall-only self-report measurements, which could impede our ability to comprehensively understand or accurately detect risk for suicide-related thoughts and behaviors. For example, an individual with low insight into their mental processes may not accurately recall their reactions to sensations of cognitive dyscontrol, which could unduly influence their ratings of items on recall-based measures of ASCC, thereby obfuscating the measurement of an important risk factor for suicide. Therefore, creating and utilizing novel methods (e.g., head-mounted display perceptual illusion challenges) for assessing such risk factors as ASCC could help improve measurement of this important construct.

Past studies have found that using head-mounted display technology is effective in significantly arousing different types of anxiety, and has even been found to be effective in reducing symptoms of many anxiety disorders as an alternative to in vivo exposure exercises (see Morina et al., 2015 or Fodor et al., 2018 for a review). Previous findings show that laboratory-based experimental psychopathology challenges (e.g., head-mounted display perceptual illusion challenges) can be used to specifically elicit fear reactivity to feelings of cognitive dyscontrol (i.e., derealization, depersonalization) and potentially serve as a viable correlate of ASCC (Capron et al., 2017a; Petkova and Ehrsson, 2008). The connection between the fear elicited from these perceptual illusion challenges and suicidality, however, remains untested. The aim of this study is to further understand how using head-mounted display perceptual illusion challenges to induce fear may allow for an alternate measure of ASCC, and help further our understanding of the relationship between ASCC and suicide. We hypothesized that the fear induced by the perceptual illusion challenges would be associated with self-reported ASCC. In addition, we hypothesized that increased fear from the challenges would predict increased self-reported suicidality. Finally, we hypothesized that the fear induced from these challenges would incrementally predict suicidality above and beyond self-reported ASCC.

2. Methods

2.1. Participants

Participants ($N = 54$) were undergraduate students recruited through a psychology department participant pool at a large Southeastern university. Participants were mostly female ($n = 38$; 69.1%) and Caucasian ($n = 49$; 89.1%), with an average age of 19.04 (SD = 1.71). Participants were eligible to further participate in the study if their ASI-3 cognitive scores were at least 1.5 standard deviations above or below the mean of the total participant pool and were provided course credit for participation. This study was approved by the university's Institutional Review Board.

2.2. Self-report measures

2.2.1. Anxiety Sensitivity Index-3 (ASI-3)

The ASI-3 (Taylor et al., 2007) is a commonly used self-report measure to assess the fear of anxiety-related symptoms. The ASI-3 was derived from the original ASI (Reiss et al., 1986) to more accurately measure the three anxiety sensitivity subfactors: cognitive, physical, and social concerns. This study used the ASI-3 cognitive subscale (6 items) to determine participant eligibility and anxiety sensitivity group assignment, which asked participants to agree or disagree with a statement (e.g., "It scares me when I am unable to keep my mind on a task") on a five-point Likert-type item scale. ASI-3 has demonstrated strong psychometric properties (Albanese et al., 2017a, 2017b, 2017c; Chavarria et al., 2015; Taylor et al., 2007), and the cognitive subscale displayed very good internal consistency in the current study ($\alpha = 0.89$). The ASI-3 was administered prior to the challenges.

2.2.2. Subjective Units of Distress Scale (SUDS)

The SUDS (Wolpe and Lang, 1964) is a self-report measure used to assess participant's current experience of fear on a scale of 0–100. Participants reported their current level of distress by answering the question, "What was the maximum amount of fear you experienced during the challenge?" The SUDS was administered at baseline and after each challenge.

2.2.3. Inventory of Depression and Anxiety Symptoms II (IDAS-II)

The IDAS-II (Watson et al., 2012) is a self-report measure assessing specific depression and anxiety symptoms. In the current study, two subscales were used: General depression (20 items) and suicidality (6 items). Scores were collected prior to the challenges. Participants were presented with a list of feelings, sensations, problems, and experiences and asked to rate how well each item describes their recent feelings and experiences during the past two weeks from 1 ("not at all") to 5 ("extremely"). For general depression, items included questions such as "I did not have much of an appetite" and "I felt depressed." For suicidality, items included questions such as "I had thoughts of suicide," "I hurt myself purposefully," and "I have cut or burned myself on purpose." The IDAS suicidality subscale has been used previously in this literature to measure suicidal thoughts and behavior (Capron et al., 2012a; Capron et al., 2013a). The IDAS-II has evidenced strong psychometric properties (Watson et al., 2012). In the current study, the suicidality subscale ($\alpha = 0.56$) had poor internal consistency and general depression subscale had excellent internal consistency (Chronbach's $\alpha = 0.91$).

2.3. Perceptual illusion laboratory challenges

2.3.1. Mannequin

This challenge was similar to the perceptual illusion exercise created by Petkova and Ehrsson (2008) and was designed to elicit feelings of swapping bodies with a mannequin. In the current study, a mannequin with gender neutral clothing (polo-shirt, blue jeans) was used

versus a bare mannequin. A mannequin was used, 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." An experimenter stroked the participant's abdomen with the brush while simultaneously brushing the mannequin's abdomen for two minutes. This challenge has successfully created the illusion that participants have switched bodies with the mannequin (Petkova and Ehrsson, 2008).

2.3.2. Handshake

The handshake challenge was identical to the perceptual illusion exercise created by Petkova and Ehrsson (2008) designed to elicit the feeling of shaking hands with one's self. An experimenter held a camera (connected to the head mounted display; HMD) in a way that presented the viewpoint of the experimenter. Participants stood directly opposite of the experimenter, wearing the HMD, which was connected to the camera on the experimenter's head. Thus, participants were facing the camera. Participants were then asked to stretch out their right arm and take hold of the experimenter's right hand, as if to shake it. This procedure allowed participants to see their physical bodies from the shoulders to slightly above the knees. Hence, they could recognize themselves and distinguish between their own arm and the arm of the experimenter. During the task, the participant and the experimenter repeatedly squeezed each other's hands, in a synchronous manner, for two minutes. This challenge has successfully created the illusion that participants are shaking hands with him/herself (Petkova and Ehrsson, 2008).

2.3.3. Opposite directions

This task was created by Capron et al. (2017a) to produce sensations of cognitive dyscontrol. In this challenge, the experimenter stood next to the participant with a camera (connected to the HMD) on a tripod (to provide smooth panning). The camera was positioned to imitate 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 four seconds." As the participant turned their head, the experimenter turned the tripod with the camera slowly in the opposite direction in a synchronous manner. This task was repeated for two minutes. The participant experienced a disconnect between their motor movements in one direction and their sight of the room moving at equal speed in the opposite direction. This challenge has successfully created feelings of cognitive dyscontrol and fear reactions (Capron et al., 2017a).

2.3.4. Rotation

This task was created by Capron et al. (2017b) to create sensations of depersonalization (i.e., out-of-body-experiences). The experimenter positioned the camera (connected to the HMD) on the tripod four feet from the participant. The camera was positioned to capture participants from the neck down, so as to see themselves spin from an "out of body" perspective. The participant was then given the following instructions: "During this task, please spin very, very slowly in a circle. To prevent you from tipping over the headset'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 two minutes. This task was designed to create 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. This challenge has been successful in eliciting feelings of depersonalization and fear reactions (Capron et al., 2017a).

2.4. Procedure

Participants were invited for the experiment appointment via the psychology department's secure research participant registration website. Participants provided informed consent upon entering the lab, and then completed baseline questionnaires. Participants then completed the four challenges in a small private experiment room in the order presented above. Challenges were not counterbalanced due to logistical issues relating to rearrangement and recalibration of the equipment. Participants removed the HMD and completed SUDS after each task. They were 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 challenge. After all challenges were completed, participants completed post-experiment measures (extensive self-report measurements were collected as part of a much larger study, but most do not pertain to this current study), were thanked for their time, and given course credit.

3. Results

3.1. Descriptive statistics and correlations

Descriptive statistics and correlations between all variables can be found in Table 1. Due to negatively skewed data within the suicidality variable, Blom's transformation was used for the primary analyses to better approximate normality (Anestis et al., 2015; Blom, 1958). However, the suicidality variable was left untransformed in the descriptives table for ease of interpretation.

Table 1
Intercorrelations between study variables.

Variable	1	2	3	4	5	6	7	8
1. IDAS-II Suicidality Subscale	–							
2. Mannequin Challenge SUDS	0.51**	–						
3. Opposite Direction Challenge SUDS	0.39**	0.64**	–					
4. Rotation Challenge SUDS	0.19	0.73**	0.74**	–				
5. Handshake Challenge SUDS	0.16	0.51**	0.63**	0.77**	–			
6. Baseline SUDS	0.28*	0.55**	0.35**	0.58**	0.78**	–		
7. ASI-3 (Cognitive)	0.34*	0.40**	0.51**	0.44**	0.39**	0.29*	–	
8. Depression	0.54**	0.52**	0.41**	0.44**	0.31*	0.30	0.51**	–
Mean	6.42	8.57	9.46	1.38	8.04	15.18	9.04	41.77
SD	0.81	13.81	17.31	3.32	14.82	23.12	4.02	14.47
Range	4.00	60.00	80.00	2.00	60.00	90.00	16.00	57.00

Note:
* $p < 0.05$.
** $p < 0.01$. SUDS = Subjective Units of Distress Scale. ASI = Anxiety Sensitivity Index.

3.2. Primary analyses

3.2.1. Hierarchical multiple linear regression exploring associations between challenges and suicidality

A multiple linear regression was used to explore which of the challenges were most associated with suicidality. A significant multiple regression model $F(4,54) = 7.85$, $p < 0.001$, $R^2 = 0.39$] revealed that self-reported SUDs following the opposite directions [$\beta = 0.36$, $t(54) = 2.11$, $p = 0.04$], handshake [$\beta = -6.23$, $t(55) = -2.71$, $p < 0.01$], and mannequin challenges [$\beta = 0.71$, $t(54) = 4.21$, $p < 0.001$] were all significantly associated with suicidality; however, the rotation challenge was not [$\beta = 0.05$, $t(54) = 0.30$, $p = 0.77$]. Unexpectedly, SUDs following the handshake challenge was negatively associated with suicidality. The opposite directions and mannequin challenges were retained for the models going forward.

3.2.2. Hierarchical multiple linear regression examining associations between self-reported ASCC and fear from perceptual challenges

A multiple linear regression was performed to understand how ASCC (ASI-3 cognitive scores) contributes to suicide-related thoughts and behaviors. As expected, a significant linear regression model $F(1,53) = 7.38$, $p = 0.01$, $R^2 = 0.12$] revealed that baseline ASI-3 cognitive scores were a significant predictor of IDAS-II suicidality subscores [$\beta = 0.35$, $t(53) = 2.72$, $p = 0.01$]. To understand if the perceptual challenges accounted for more of the variance for suicidality than ASI-3 cognitive scores, a multiple regression analysis was performed by regressing IDAS-II suicidality scores on the combined total SUDs scores for the perceptual challenges and ASI-3 cognitive concerns. The overall model was significant $F(1,52) = 7.92$, $p = 0.001$, $R^2 = 0.23$] and found that total SUDs scores were associated with IDAS-II suicidality scores [$\beta = 0.39$ $t(52) = 2.75$, $p = 0.008$] even when accounting for self-reported ASI-3 cognitive concerns [$\beta = 0.15$, $t(52) = 1.03$, $p = 0.31$], indicating that reactivity to the perceptual illusion challenges accounted for significantly more variance ($p = 0.008$) in IDAS-II suicidality scores than the self-reported ASI-3 cognitive concerns ($+0.11$ R^2). In addition, the higher standardized beta value for the SUDS scores indicates that the fear elicited by the perceptual illusion challenges may be a more precise correlate of suicidality than ASI-3 cognitive scores.

3.2.3. Hierarchical multiple linear regression examining associations between self-reported ASCC and fear from perceptual challenges with added covariates

Baseline SUDS and IDAS-II depression scores were put into the model for step one with IDAS-II suicidality scores being the outcome variable. These variables were chosen as covariates due to their relations with suicidality. The model was significant [$F(2, 52) = 11.03$, $p < 0.001$, $R^2 = 0.30$] with IDAS-II depression scores significantly predicting IDAS-II suicidality scores [$\beta = 0.47$, $t(52) = 3.58$, $p = 0.001$]; however, baseline SUDS [$\beta = 0.15$, $t(52) = 1.12$, $p = 0.27$] was not significant.

In the second step, IDAS-II suicidality was then regressed on baseline SUDS, IDAS-II depression, and ASI-3 cognitive scores. The model was significant [$F(3,51) = 7.23$, $p < 0.001$, $R^2 = 0.30$], but did not increase the variance accounted for, $p = 0.85$. Only IDAS-II depression was a significant predictor of suicidality [$\beta = 0.45$, $t(51) = 3.13$, $p = 0.003$].

In the third step, the self-reported SUDS scores were added to the model to reflect the fear elicited by the perceptual challenges (Table 2). The overall model was significant [$F(4,50) = 7.37$, $p < 0.001$, $R^2 = 0.37$], and had a significant change in the variance accounted for by this addition to the model, $p = 0.02$. SUDS scores from the perceptual challenges [$\beta = 0.69$, $t(50) = 2.40$, $p = 0.02$], and IDAS-II depression scores [$\beta = 0.40$, $t(50) = 2.78$, $p = 0.008$] were all significant predictors of suicidality; however, ASI-3 cognitive concern scores and baseline SUDS were not. These results suggest that self-reported ASCC is a significant predictor without depression and baseline SUDS as covariates. SUDS from the perceptual illusion challenges, however, predicts IDAS-II suicidality above and beyond self-reported ASCC when these covariates are added to the model.

Table 2
Hierarchical regression between covariates, ASCC, and SUDS from challenges with IDAS-II suicidality subscores as outcome variable.

Variable	B	SE	p	95% CI for B	F	R^2
Step 1					11.025**	0.298
Depression	0.392	0.008	0.008	0.006–0.038**		
Baseline SUDS	−0.458	0.003	0.110	−0.012–0.001		
Step 2					7.225**	0.298
ASI-3 (cog)	0.007	0.026	0.960	−0.050–0.053		
Step 3					7.372**	0.371
Challenge SUDS	0.691	0.007	0.020	0.003–0.032**		

Note.
** $p < 0.001$. ASI-3 (cog) = Anxiety Sensitivity Index Cognitive Concerns Subscale Score; SUDS = Subjective Units of Distress Scale.

3.3. Exploratory analyses

3.3.1. Hierarchical multiple linear regression examining associations between self-reported ASCC and suicidality with added covariates

To better elucidate causality of how these variables interact, we ran the second regression using the model using baseline SUDS, ASI-3 cognitive scores, and IDAS-II suicidality subscale scores as predictor variables, and SUDS from the challenges as the outcome variable (Table 3). Baseline SUDS and SUDS from the challenges were put into the model for step one with SUDS from the challenges being the outcome variable. The model was significant [$F(2, 52) = 14.83$, $p < 0.001$, $R^2 = 0.36$] with both IDAS-II depression scores [$\beta = 0.36$, $t(52) = 3.06$, $p = 0.01$] and baseline SUDS significantly predicting IDAS-II suicidality scores [$\beta = 0.38$, $t(52) = 3.18$, $p = 0.01$].

In the second step, SUDS from the challenges were then regressed on baseline SUDS, IDAS-II depression, and ASI-3 cognitive scores. The model was significant [$F(3,51) = 12.78$, $p < 0.001$, $R^2 = 0.43$], and significantly increased the variance accounted for by 5.7% ($p = 0.02$). Baseline SUDS [$\beta = 0.34$, $t(51) = 3.00$, $p = 0.01$] and ASI-3 cognitive scores [$\beta = 0.31$, $t(51) = 2.43$, $p = 0.02$] were both significant predictors of SUDS from the perceptual illusion challenges.

In the third step, IDAS-II suicidality subscores were added to the model. The overall model was significant [$F(4,50) = 11.29$, $p < 0.001$, $R^2 = 0.48$], and had a significant change in the variance (3.6%) accounted for by this addition to the model, $p = 0.04$. IDAS-II suicidality subscores [$\beta = 0.26$, $t(50) = 2.08$, $p = 0.04$], baseline SUDS [$\beta = 0.32$, $t(50) = 2.86$, $p = 0.01$], and ASI-3 cognitive concern scores were significant [$\beta = 0.30$, $t(50) = 2.41$, $p = 0.02$]; however, and IDAS-II depression scores were not ($p = 0.59$). This model suggests that IDAS-II suicidality subscores predicts SUDS from the perceptual illusion challenges above depression, self-reported ASCC, and baseline SUDS.

Table 3
Hierarchical regression between covariates, ASCC, and suicidality regressed with SUDS from challenges as outcome variable.

Variable	B	SE	p	95% CI for B	F	R^2
Step 1					14.831**	0.363
Depression	0.077	0.310	0.586	−0.453– 0.793		
Baseline SUDS	0.316	2.220	0.006	1.872–10.790***		
Step 2					12.784**	0.396
ASI-3 (cog)	0.299	0.864	0.020	0.343– 3.815*		
Step 3					11.291**	0.475
IDAS- II Suicidality Subscale	0.255	4.277	0.043	0.003–0.032*		

Note. *$p < 0.05$. **$p < 0.01$. ***$p < 0.001$. ASI-3 (cog) = Anxiety Sensitivity Index Cognitive Concerns Subscale Score. SUDS = Subjective Units of Distress Scale.

Table 4
Hierarchical Regression between ASCC, baseline SUDS, suicidality, and SUDS from challenges with depression as outcome the variable.

Variable	B	SE	p	95% CI for B	F	R^2
Step 1					7.09*	0.10
Baseline SUDS	0.10	1.08	0.39	−1.24–3.10		
Step 2					13.66***	0.32***
ASI-3 (cog)	0.36	0.38	<0.01	0.37–1.91**		
Step 3					14.63***	0.43**
IDAS-II Suicidality Subscale	0.35	1.87	<0.01	1.75–9.27**		
Step 4					10.90***	0.42
SUDS from challenges	0.08	0.06	0.59	−0.09–0.16		

Note.
*** $p < 0.001$. ** $p < 0.01$. * $p < 0.05$. ASI-3 (cog) = Anxiety Sensitivity Index Cognitive Concerns Subscale Score. SUDS = Subjective Units of Distress Scale. IDAS-II = Inventory of Depression and Anxiety Symptoms - Second Version.

3.3.2. Hierarchical multiple linear regression examining associations between self-reported ASCC, baseline SUDS, suicidality, SUDS from challenges, and depression as the outcome variable

For our last exploratory model, we regressed ASI-3 cognitive scores, baseline SUDS, IDAS-II suicidality subscores, and SUDS from the perceptual illusion challenges on depression to better discern if stress reactivity to the perceptual illusion challenges was specific only in predicting suicidality, or depression as well (Table 4). As shown in Table 4, in the fourth step of the model, SUDS from the perceptual illusion challenges was not a significant predictor of depression ($p < 0.59$), nor was baseline SUDS ratings ($p < 0.39$). Only IDAS-II suicidality subscores and ASI-3 cognitive scores were significant predictors.

4. Discussion

Prior literature has consistently found a relationship between anxiety and suicide. Recent research has suggested that ASCC are associated with suicide-related thoughts and behaviors, and could be one important component in understanding the connection between anxiety disorders and suicide-related thoughts and behaviors. Until recently, however, measuring ASCC has been confined to recall-only self-report measures. Our findings replicate previous studies showing that ASCC is significantly associated with suicide-related thoughts and behaviors (e.g., Capron et al., 2013a, 2013b), and extended this line of work by showing that a previously validated perceptual illusion challenge (Capron et al., 2017a) is also associated with suicidality. In addition, fear associated with head-mounted display perceptual illusion challenges was more highly associated with IDAS suicidality scores than the most commonly used ASCC self-report measure (i.e., ASI-3). These results further the line of research implicating ASCC in suicide-related thoughts and behaviors by demonstrating these effects across multiple measurement domains. Second, the observed findings provide some initial evidence that the novel ASCC challenges presented in Capron et al. (2017a) may have measurement utility as a correlate for suicide-related thoughts and behaviors by providing a lab-based measure of ASCC that mitigates limitations associated with recall-based self-report measures (e.g., insight, memory biases). These results could have important implications not only for measurements of suicide risk correlates, but for populations with elevated depersonalization/derealization symptoms and suicide risk, such as individuals with PTSD-dissociative subtype (Stein et al., 2013).

The exploratory analyses performed in this study point found that suicidality and stress reactivity to the perceptual illusion challenges were significantly associated after covarying for initial stress/mood (baseline SUDS), depression, and ASCC, and were the only two variables to remain significantly related in both of these models. This is important for supporting the relationship stability between these two variables, and provides further evidence of stress reactivity from perceptual illusion challenges to be a correlate of suicide-related thoughts and behaviors. However, because both of these models were both significant predictor variables as well as outcome variables to one another, further research is needed to uncover the pathways of these variables to understand how they conceptually relate to one another. Lastly, we found that perceptual illusion challenges were a unique predictor of suicidality as opposed to being correlated with both depression and suicidality, suggesting that these perceptual challenges may be associated with properties that are distinct to suicide-related thoughts and behaviors.

The association between fear reactivity to the cognitive dyscontrol challenges and suicidality may also have treatment implications. Treatment manuals suggest utilizing exposure techniques that elicit feelings of derealization and depersonalization (Craske and Barlow, 2006; Taylor, 2000), such as mirror staring and dot staring exercises. However, these have been noted to be ineffective for many patients (Licket et al., 2008). In addition, although research has found support for challenges that evoke dissociative symptoms, these studies did not directly examine the relationship between the challenges and ASCC or fear reactivity (Leonard et al., 2000; Lickel et al., 2008), and these challenges often showed overlap with other subcomponents (i.e., physical concerns) of AS. Currently, there is a noticeable lack of laboratory-based challenges designed to evoke sensations specific to ASCC that can be used for repeated exposures. In fact, the head-mounted display challenges used in the current study appear to be the only effective challenge in the literature for AS that specifically targets ASCC (Capron et al., 2017a). Based on our results, future research should further explore the direction of causality between suicidality and stress reactivity to these ASCC challenges, and whether repeated exposures to relevant perceptual illusion challenges (i.e., direction, abdomen) have an effect on reducing ASCC and suicide-related thoughts and behaviors.

Finally, it is plausible that repeated exposure to the ASCC challenges may be particularly useful as a transdiagnostic treatment for individuals with psychopathology marked by elevated ASCC and comorbid suicidality. For example, ASCC has been consistently associated with PTSD (Boffa et al., 2016; Norr et al., 2016a; Taylor, 2003) especially among those with a history of traumatic brain injury (Albanese et al., 2017a, 2017b). Moreover, recent evidence suggests that ASCC may serve as a mechanism linking PTSD and suicidality (Raines et al., 2017; Stanley et al., 2017). This, combined with evidence showing that ASCC interventions reduce PTSD symptoms (Allan et al., 2015; Short et al., 2017) and suicidality (Schmidt et al., 2014, 2017) suggests that the reduction of ASCC may simultaneously ameliorate PTSD symptoms and suicidality.

4.1. Limitations

There are several important limitations to this study. First, suicidality was measured prior to the challenges, making interpretations about changes to suicide risk as a result of the challenges impossible. Suicidality was, however, assessed in the laboratory immediately before the challenges were administered, which still allows for interpretations regarding the associations between ASCC and suicide risk. Second, this was a fairly low risk sample, with no students reporting previous self-injurious behavior. Although, passive ideation ($n = 10$, 17.9%) and serious thoughts of suicide ($n = 4$, 7.2%) rates for this sample were comparable to other studies with undergraduate samples (Drum et al., 2009). Additionally, the reliability score for the suicidality subscale was low (0.56), which has been found to occur in low sample size studies with non-normal distributions (Sheng and Sheng, 2012). In the current study, 40 participants (71.4%) did not endorse any suicidality symptoms. Larger sample sizes, particular those with increased ASCC and suicide risk, are needed to make more generalizable claims about the relationship between behavioral correlates of ASCC and suicide risk. Further, a possible order effect could be a confounding factor in our results, as we were unable to counterbalance the challenges due to

logistical issues (i.e., small testing space) and creating different combinations for the order of these challenges was deemed to be more detrimental to the execution of this study. Lastly, fear reactivity was measured via self-report measure. Although the current protocol most likely allowed for a more accurate interpretation of the participants' fear level than relying on recall of a previous ASCC, future studies should implement a psychophysiological or behavioral measure concomitantly in order to optimize the accuracy of these interpretations.

4.2. Conclusion

Suicide remains a major public health concern, with recent data evidencing that suicide rates have increased over the last twenty years (CDC, 2015). Anxiety and suicide have been correlated across many studies, with recent evidence suggesting that ASCC could play a role in this connection. This relationship, however, has largely been based on recall-based self-report assessment that is likely to reflect only a portion of knowledge for the connection between anxiety, ASCC, and suicide. The current study used a novel alternative measure of ASCC to more precisely measure and predict the contribution of ASCC to suicidality. Importantly, this study provides evidence for a method to induce ASCC-relevant fear, which could allow for greater understanding regarding how ASCC contributes to suicide risk.

Conflicts of interest

All authors report no conflict of interest

Contributors

BWB designed the study and drafted the manuscript with RLM, BJA, and NSS. BJA and BWB undertook the statistical analyses. NBS and DWC edited and revised drafts of the manuscript. All authors contributed to and have approved the final manuscript.

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Declarations of interest

none

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2018.12.106.

References

Albanese, B.J., Boffa, J.W., Macatee, R.J., Schmidt, N.B., 2017a. Anxiety sensitivity mediates gender differences in post-concussive symptoms in a clinical sample. Psychiatry Res. 252, 242–246.
Albanese, B.J., Macatee, R.J., Schmidt, N.B., Leeson, B., Clemans, T.A., Mintz, J., Rudd, M.D., Bryan, C.J., 2017b. Interactive effects of traumatic brain injury and anxiety sensitivity cognitive concerns on post-traumatic stress among active duty soldiers. Cognit. Therapy Res. 41 (6), 902–910.
Albanese, B.J., Macatee, R.J., Schmidt, N.B., Leeson, B., Clemans, T.A., Mintz, J., Bryan, C.J., et al., 2017c. Interactive effects of traumatic brain injury and anxiety sensitivity cognitive concerns on post-traumatic stress among active duty soldiers. Cognit. Therapy Res. 41 (6), 902–910.
Allan, N.P., Short, N.A., Albanese, B.J., Keough, M.E., Schmidt, N.B., 2015. Direct and mediating effects of an anxiety sensitivity intervention on posttraumatic stress disorder symptoms in trauma-exposed individuals. Cogn. Behav. Ther. 44 (6), 512–524.
Anestis, M.D., Khazem, L.R., Mohn, R.S., Green, B.A., 2015. Testing the main hypotheses of the interpersonalpsychological theory of suicidal behavior in a large diverse sample of United States military personnel. Compr. Psychiatry 60, 78–85.
Beck, A.T., Kovacs, M., Weissman, A., 1979. Assessment of suicidal intention: the scale for suicide ideation. J. Consult. Clin. Psychol. 47 (2), 343.
Blom, G., 1958. Statistical Elements and Transformed Beta Variables. Wiley, New York.
Boffa, J.W., Norr, A.M., Raines, A.M., Albanese, B.J., Short, N.A., Schmidt, N.B., 2016. Anxiety sensitivity prospectively predicts posttraumatic stress symptoms following a campus shooting. Behav. Therapy 47 (3), 367–376.
Busch, K.A., Fawcett, J., Jacobs, D.G., 2003. Clinical correlates of inpatient suicide. J. Clin. Psychiatry 64 (1), 14–19.
Capron, D.W., Blumenthal, H., Medley, A.N., Lewis, S., Feldner, M.T., Zvolensky, M.J., Schmidt, N.B., 2012a. Anxiety sensitivity cognitive concerns predict suicidality among smokers. J. Affect. Disord. 138 (3), 239–246.
Capron, D.W., Cougle, J.R., Ribeiro, J.D., Joiner, T.E., Schmidt, N.B., 2012b. An interactive model of anxiety sensitivity relevant to suicide attempt history and future suicidal ideation. J. Psychiatry Res. 46 (2), 174–180.
Capron, D.W., Fitch, K., Medley, A., Blagg, C., Mallott, M., Joiner, T., 2012c. Role of anxiety sensitivity subfactors in suicidal ideation and suicide attempt history. Depress. Anxiety 29 (3), 195–201.
Capron, D.W., Kotov, R., Schmidt, N.B., 2013a. A cross-cultural replication of an interactive model of anxiety sensitivity relevant to suicide. Psychiatry Res. 205 (1), 74–78.
Capron, D.W., Norr, A.M., Albanese, B.J., Schmidt, N.B., 2017a. Fear reactivity to cognitive dyscontrol via novel head-mounted display perceptual illusion exercises. J. Affect. Disord. 217, 138–143.
Capron, D.W., Norr, A.M., Allan, N.P., Schmidt, N.B., 2017b. Combined "top-down" and "bottom-up" intervention for anxiety sensitivity: Pilot randomized trial testing the additive effect of interpretation bias modification. J. Psychiatr. Res. 85, 75–82.
Capron, D.W., Norr, A.M., Macatee, R.J., Schmidt, N.B., 2013b. Distress tolerance and anxiety sensitivity cognitive concerns: testing the incremental contributions of affect dysregulation constructs on suicidal ideation and suicide attempt. Behav. Therapy 44 (3), 349–358.
Centers for Disease Control and Prevention (CDC), 2015. Suicide: At a Glance. Retrieved from. https://www.cdc.gov/violenceprevention/pdf/suicide-datasheet-a.pdf.
Chavarria, J., Allan, N.P., Boffa, J.W., Albanese, B.J., Schmidt, N.B., Zvolensky, M.J., 2015. Decomposing the relationship between anxiety sensitivity and alcohol use. J. Stud. Alcohol Drugs 76 (6), 957–961.
Craske, M.G., Barlow, D.H., 2006. Mastery of Your Anxiety and Worry. Oxford University Press.
Curtin, S.C., Warner, M., Hedegaard, H., 2016. Increase in suicide in the United States, 1999–2014. US Department of Health and Human services, Centers For Disease Control and Prevention. National Center for Health Statistics.
Drum, D.J., Brownson, C., Denmark, A.B., Smith, S.E., 2009. New data on the nature of suicidal crises in college students: Shifting the paradigm. Prof. Psychol. Res. Pract. 40 (3), 213–222.
Fodor, L.A., Coteț, C.D., Cuijpers, P., Szamoskozi, Ș., David, D., Cristea, I.A., 2018. The effectiveness of virtual reality based interventions for symptoms of anxiety and depression: a meta-analysis. Sci. Rep. 8 (1), 10323.
Holloway, W., McNally, R.J., 1987. Effects of anxiety sensitivity on the response to hyperventilation. J. Abnorm. Psychol. 96 (4), 330.
Leonard, K.N., Telch, M.J., Owen, K.K., 2000. Fear response to dissociation challenge. Anxiety Stress Coping 13 (4), 355–369.
Lickel, J., Nelson, E., Lickel, A.H., Deacon, B., 2008. Interoceptive exposure exercises for evoking depersonalization and derealization: a pilot study. J. Cognit. Psychother. 22 (4), 321.
Morina, N., Ijntema, H., Meyerbröker, K., Emmelkamp, P.M., 2015. Can virtual reality exposure therapy gains be generalized to real-life? A meta-analysis of studies applying behavioral assessments. Behav. Res. Ther. 74, 18–24.
Nock, M.K., Park, J.M., Finn, C.T., Deliberto, T.L., Dour, H.J., Banaji, M.R., 2010. Measuring the suicidal mind: implicit cognition predicts suicidal behavior. Psychol. Sci. 21 (4), 511–517.
Norr, A.M., Albanese, B.J., Boffa, J.W., Short, N.A., Schmidt, N.B., 2016a. The relationship between gender and PTSD symptoms: Anxiety sensitivity as a mechanism. Personal. Indiv. Differ. 90, 210–213.
Norr, A.M., Allan, N.P., Macatee, R.J., Capron, D.W., Schmidt, N.B., 2016b. The role of anxiety sensitivity cognitive concerns in suicidal ideation: a test of the depression-distress amplification model in clinical outpatients. Psychiatry Res. 238, 74–80.
Oglesby, M.E., Capron, D.W., Raines, A.M., Schmidt, N.B., 2015. Anxiety sensitivity cognitive concerns predict suicide risk. Psychiatry Res. 226 (1), 252–256.
Osman, A., Gutierrez, P.M., Smith, K., Fang, Q., Lozano, G., Devine, A., 2010. The anxiety sensitivity index–3: analyses of dimensions, reliability estimates, and correlates in nonclinical samples. J. Pers. Assess. 92 (1), 45–52.
Petkova, V.I., Ehrsson, H.H., 2008. If I were you: perceptual illusion of body swapping. PLoS One 3 (12), e3832.
Raines, A.M., Capron, D.W., Stentz, L.A., Walton, J.L., Allan, N.P., McManus, E.S., Franklin, C.L., et al., 2017. Posttraumatic stress disorder and suicidal ideation, plans, and impulses: The mediating role of anxiety sensitivity cognitive concerns among veterans. J. Affect. Disord. 222, 57–62.
Reiss, S., Peterson, R.A., Gursky, D.M., McNally, R.J., 1986. Anxiety sensitivity, anxiety frequency and the prediction of fearfulness. Behav. Res. Therapy 24 (1), 1–8.
Schmidt, N.B., 1999. Examination of differential anxiety sensitivities in panic disorder: a test of anxiety sensitivity subdomains predicting fearful responding to a 35% CO_2 challenge. Cognit. Therapy Res. 23 (1), 3–20.
Schmidt, N.B., Capron, D.W., Raines, A.M., Allan, N.P., 2014. Randomized clinical trial evaluating the efficacy of a brief intervention targeting anxiety sensitivity cognitive concerns. J. Consult. Clin. Psychol. 82 (6), 1023.
Schmidt, N.B., Norr, A.M., Allan, N.P., Raines, A.M., Capron, D.W., 2017. A randomized

clinical trial targeting anxiety sensitivity for patients with suicidal ideation. J. Consult. Clin. Psychol. 85 (6), 596.
Sheng, Y., Sheng, Z., 2012. Is coefficient alpha robust to non-normal data? Sweating the Small Stuff: Does Data Cleaning and Testing of Assumptions Really Matter in the 21st Century? Front. Psychol. 4, 370.
Short, N.A., Boffa, J.W., Norr, A.M., Albanese, B.J., Allan, N.P., Schmidt, N.B., 2017. Randomized clinical trial investigating the effects of an anxiety sensitivity intervention on posttraumatic stress symptoms: A replication and extension. J. Trauma Stress 30 (3), 296–303.
Stanley, I.H., Hom, M.A., Spencer-Thomas, S., Joiner, T.E., 2017. Examining anxiety sensitivity as a mediator of the association between PTSD symptoms and suicide risk among women firefighters. J. Anxiety Disord. 50, 94–102.
Stein, D.J., Koenen, K.C., Friedman, M.J., Hill, E., McLaughlin, K.A., Petukhova, Kessler, R.C., et al., 2013. Dissociation in posttraumatic stress disorder: evidence from the world mental health surveys. Biol. Psychiatry 73 (4), 302–312.
Taylor, S., 2000. Understanding and Treating Panic disorder: Cognitive-Behavioural Approaches. John Wiley & Sons Ltd.
Taylor, S., 2003. Anxiety sensitivity and its implications for understanding and treating PTSD. J. Cognit. Psychother. 17 (2), 179–186.
Taylor, S., Zvolensky, M.J., Cox, B.J., Deacon, B., Heimberg, R.G., Ledley, D.R., Coles, M., et al., 2007. Robust dimensions of anxiety sensitivity: development and initial validation of the anxiety sensitivity index-3. Psychol. Assess. 19 (2), 176.
Telch, M.J., Silverman, A., Schmidt, N.B., 1996. Effects of anxiety sensitivity and perceived control on emotional responding to caffeine challenge. J. Anxiety Disord. 10 (1), 21–35.
Valentiner, D.P., Gutierrez, P.M., Blacker, D., 2002. Anxiety measures and their relationship to adolescent suicidal ideation and behavior. J. Anxiety Disord. 16 (1), 11–32.
Watson, D., O'Hara, M.W., Naragon-Gainey, K., Koffel, E., Chmielewski, M., Kotov, R., Stasik, S.M., Ruggero, C.J., 2012. Development and validation of new anxiety and bipolar symptom scales for an expanded version of the IDAS (the IDAS-II). Assessment 19 (4), 399–420.
Wilson, T.D., 2009. Know thyself. Perspectives on Psychological Science 4 (4), 384–389.
Wolpe, J., Lang, P.J., 1964. A fear survey schedule for use in behaviour therapy. Behav. Res. Ther. 2 (1), 27–30.