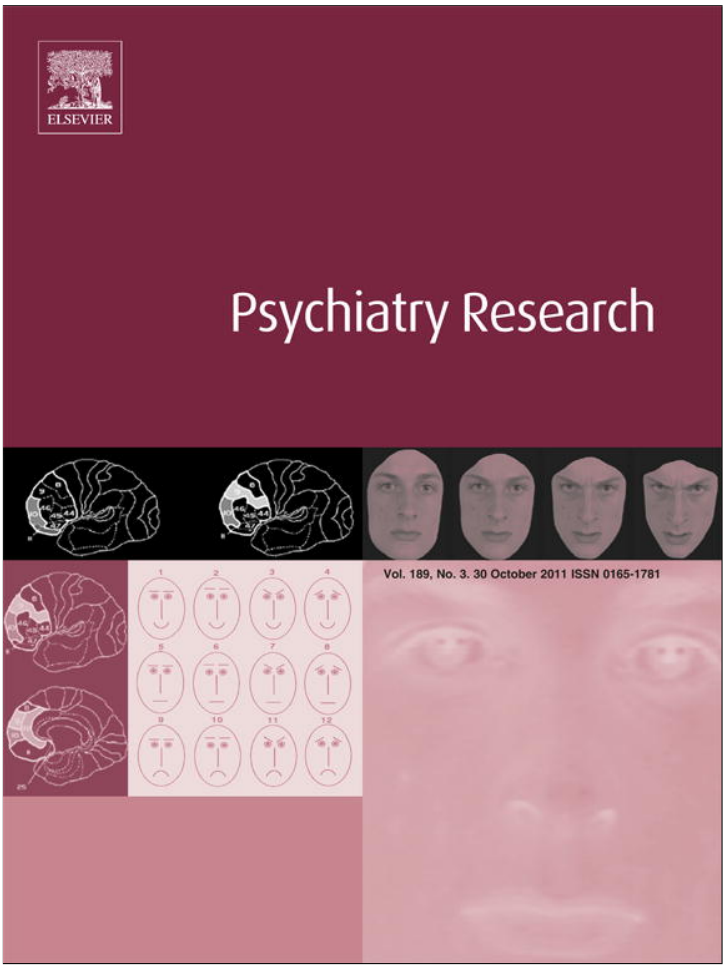

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Clarifying the role of pain tolerance in suicidal capability

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ABSTRACT

Joiner's (2005) interpersonal-psychological theory of suicide hypothesizes that painful and provocative events increase pain tolerance. The theory further proposes that increased pain tolerance represents one component of increased suicidal capability. Although initial studies have been consistent with this model, several key aspects remain untested. In 67 undergraduates, we investigated associations among painful and provocative events, nonsuicidal self-injury, acquired capability for suicide, and pain tolerance, threshold, and perceived intensity. Results were highly consistent with the interpersonal-psychological theory: a multiple mediation model specified that pain tolerance – but not other pain variables – accounted for significant variance within the association between painful and provocative events and acquired capability for suicide. These results held even when the pain tolerance item was removed from the suicidal capability questionnaire. Results also supported the interpersonal-psychological theory hypothesis that nonsuicidal self-injury represents an important painful and provocative event that increases suicidal capability. Specifically, participants with a history of nonsuicidal self-injury displayed increased suicidal capability and decreased pain perception. Overall, these results indicate that pain tolerance plays an important and specific role in suicidal capability.

1. Introduction

In 2007, in the United States alone, there were nearly one million suicide attempts, with a suicide completion occurring every 15 min (McIntosh, 2010). Suicidality is a major public health problem and research is desperately needed to gain greater insight into why individuals engage in these behaviors. To this end, Joiner (2005) proposed the interpersonal-psychological theory of suicide. It states that suicide is most likely to occur when an individual has both a high desire for suicide (i.e., perceived burdensomeness and thwarted belongingness; see Joiner, 2005) and a high capability for suicide (i.e., an ability to overcome the basic self-preservation instinct; see Ohman and Mineka, 2001). This theory provides an explanation for why most people who have a high desire for suicide never attempt suicide. It also explains previously unaccounted for patterns such as relatively high suicide rates in physicians (Cornette et al., 2009) and military personnel (Selby et al., 2010). Perhaps most importantly, the interpersonal-psychological theory of suicide has generated new therapeutic targets and strategies (see Joiner and Van Orden, 2008).

There is a growing literature aimed at evaluating the components of this new theory — particularly desire for suicide; however, there is relatively little empirical data on perhaps the most novel component of this theory, capability for suicide (Van Orden et al., 2010). Stringent tests of this theory are needed to advance knowledge about the nature of suicidality and how to prevent such behaviors. In the present study, we provided stringent tests of this theory's hypotheses about the role of pain tolerance in suicidal capability.

The interpersonal-psychological theory of suicide posits that the acquired capability for suicide (ACS) arises from painful and provocative experiences (PPEs; e.g., contact sports, witnessing abuse, getting a tattoo). There are two aspects of ACS: lowered fear of death and increased pain tolerance (Van Orden et al., 2010). Via opponent processes (see Solomon, 1980), PPEs generate habituation to the fear associated with death and the painfulness associated with many methods of suicide; in other words, PPEs increase ACS. Although there are no published longitudinal studies of this hypothesis and few studies have used methods other than self-report, initial tests are consistent with these predictions. Using questionnaires developed to assess a history of PPEs and ACS, Van Orden et al. (2008) found that these two constructs were significantly correlated ($r = 0.28$) in a sample of individuals with a history of suicide attempts. Bender et al. (2011) found a similar correlation in a clinical sample ($r = 0.35$) and an even higher correlation in an undergraduate sample ($r = 0.42$).

The role of pain tolerance in the link between PPEs and ACS has received even less attention. Several studies have found that pain tolerance is associated with various aspects of suicidality (e.g., Orbach et al., 1996); however, only one published study has examined the association between pain tolerance and PPEs and ACS. Bender et al. (2011) found that pain tolerance was moderately correlated with both PPEs and ACS ($rs = 0.40$ and 0.42). Although this study was not

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longitudinal, its results are consistent with the interpersonal-psychological theory hypothesis that PPEs increase ACS partly by increasing pain tolerance (see Fig. 1). Nonetheless, these results are also consistent with a plausible alternative model (see Fig. 2). In this model, pain tolerance is not a crucial link between PPEs and ACS; rather, it is coincidentally and independently associated with PPEs and ACS. These independent associations may occur because natural pain tolerance may be normally distributed in the population. Individuals with a naturally higher pain tolerance may be: (a) naturally more capable of engaging suicidality; and (b) more likely to engage in PPEs because they find them less aversive. The role of pain tolerance in the PPE–ACS association is among the most novel and important aspects of the interpersonal-psychological theory of suicide. Accordingly, it is crucial that the alternative model be ruled out.

The interpersonal-psychological theory of suicide also specifies that pain tolerance – but not other pain variables such as threshold and perceived intensity – is important to the PPE–ACS relationship (Van Orden et al., 2010). Given extensive evidence that suicidality is correlated with several non-tolerance pain variables (e.g., Orbach et al., 1996; Kemperman et al., 1997; Matsumoto et al., 2008), there is reason to doubt a specific role for pain tolerance. The theory specifies a role for pain tolerance because it posits that one of the most important proximate factors of suicide may be the "cognitive appraisal that the pain involved in the chosen method of suicide is tolerable" (Van Orden et al., 2010, p. 586). Although Bender et al. (2011) found that PPEs and ACS are correlated with pain tolerance, no published study has examined the association between these constructs and other pain measures such as pain threshold or perceived intensity. A stringent test of this hypothesis is necessary to provide discriminant validity for this fundamental aspect of the interpersonal-psychology theory of suicide.

We employed a multiple mediation model (see Preacher and Hayes, 2008) to test the specific role of pain tolerance in the PPE–ACS relationship. Multiple mediation models simultaneously test the ability of multiple variables to account for variance in a given association between two other variables (e.g., PPE–ACS). Importantly, this technique controls for collinearity among potential mediators, meaning that all significant effects are unique effects (Preacher and Hayes, 2008). Because the present study did not include longitudinal data, these analyses cannot be employed to infer causality; however, they may still be utilized to examine the degree to which pain variables account for the PPE–ACS association. Accordingly, this technique allowed for a powerful and efficient test of hypotheses about the relative contributions of multiple pain variables to the PPE–ACS association. We further stringently tested these hypotheses by repeating analyses with a version of the ACS scale that does not include the potentially confounding item "I can tolerate a lot more pain than most people."

In addition to examining associations with a general index of PPEs (cf. Van Orden et al., 2008; Bender et al., 2011), we investigated associations with a specific PPE, nonsuicidal self-injury (NSSI; e.g., intentionally cutting or burning the skin without suicidal intent, see Nock, 2010). This allowed for a test of the hypothesis that NSSI is an important PPE that increases ACS (Joiner, 2005). Indeed, NSSI is associated with both increased pain endurance (Hooley et al., 2010) and suicidal self-injury (Andover and Gibb, 2010); nevertheless, there is no direct empirical evidence that NSSI is specifically associated with ACS.

Fig. 1. Interpersonal-psychological theory's model for the role of pain tolerance in PPE–ACS.

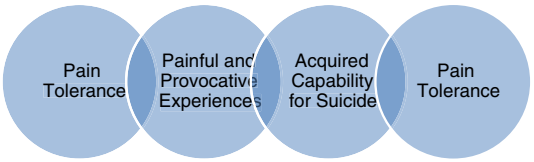

Fig. 2. Alternative model for the role of pain tolerance in PPE–ACS.

According to the interpersonal-psychological theory of suicide, suicidal capability is a necessary but insufficient factor for suicide (i.e., suicidal desire must also be present). This means that the vast majority of individuals with a high capability for suicide should never have a desire for suicide or engage in suicidal behaviors (Joiner, 2005; Van Orden et al., 2010). For example, Van Orden et al. (2008) found that a measure of ACS did not correlate with measures of depression or suicidal ideation. Accordingly, the PPE–ACS association should exist in a nonclinical population; moreover, this relationship may be even stronger and more cleanly observed in a nonclinical population because it is less tainted by factors associated with desire for suicide (e.g., low distress tolerance; Anestis et al., 2011a,b). As such, we utilized a nonclinical population in the present study.

2. Methods

2.1. Subjects

Participants were 67 young adults: 47 females, 20 males; 80.60% European American, 8.90% Asian American, 7.46% African American, and 2.99% Hispanic American. Ages ranged from 18 to 29 ($M = 19.25$, $SD = 2.07$). We recruited participants from two sources: (1) introductory psychology classes that included a research participation option ($n = 41$); and (2) campus-wide email advertisements that offered payment of $20 for participation in the study ($n = 26$). These latter participants were recruited from email advertisements sent to individuals based on their NSSI scores on a screening questionnaire that was administered as part of a separate study during a summer college orientation program. Of these participants, 10 were controls and 16 (11 females) had a history of "severe" NSSI (i.e., cutting, burning, or scraping). Many studies include a wider variety of behaviors as NSSI (e.g., skin-picking, scab-picking, lip-biting). In an effort to accurately reflect clinically-relevant NSSI behaviors, we elected to include only intense behaviors that are associated with at least a moderate degree of tissue damage. Descriptive statistics for NSSI are presented elsewhere (Franklin et al., 2010).

Analyses indicated that ethnicity and age were not significantly associated with PPEs, ACS, or pain variables. Inconsistent with previous findings (e.g., Klatzkin et al., 2010), analyses also indicated that, compared to females, males did not have significantly higher pain thresholds ($d = 0.26$), higher pain tolerances ($d = 0.25$), or lower pain intensity at threshold ($d = 0.03$) or tolerance points ($d = 0.05$). It is likely that this lack of gender differences is due in part to (a) colder water than that employed in most cold pressor studies (see below), and (b) the abnormal pain perception of females with a history of NSSI (see below). Consistent with previous findings (e.g., Van Orden et al., 2008), males displayed significantly higher levels of PPEs ($t[65] = 2.99$, $P < 0.01$, $d = 0.81$) and ACS ($t[65] = 1.85$, $P < 0.05$, $d = 0.50$). Because of the potential impact of NSSI history and gender on results, these two variables were used as covariates during multiple mediation analyses of the PPE–ACS association. Participants completed informed consent forms at the beginning of the study. All materials, measures, methods, and procedures were approved by the Institutional Review Board of the University of North Carolina at Chapel Hill.

2.2. Procedures

The present investigation was conducted as part of a larger study described elsewhere (Franklin et al., 2010). This larger study was focused primarily on the functions of NSSI; the present investigation employs the same sample but tests a distinct, suicide-relevant hypothesis. Relevant to the present investigation, participants first filled out questionnaires assessing PPEs and ACS. During the experimental portion of the study, participants completed a speech task (see Franklin et al., 2010), which was immediately followed by a painful task (i.e., the cold pressor task). Because stress induced by the speech task could conceivably influence results, in mediational analyses

we covaried participants' self-reported subjective units of distress that were assessed immediately after the speech task. During the cold pressor task, we measured participants' pain threshold, tolerance, and pain intensity ratings. Below we provide more information about these measures.

2.3. Questionnaires

2.3.1. Painful and Provocative Events Scale (PPE scale; Bender et al., 2011)

The PPE scale assesses the number of painful and provocative events a person has experienced. The full version of the PPE scale is a 25-item questionnaire that asks the individual to report how many times they have experienced certain events (e.g. played contact sports, got a piercing, jumped from high places). Bender et al. (2011) and Van Orden et al. (2008) employed a shortened and altered version of this measure. The PPE scale demonstrates good reliability (Cronbach's alpha = 0.90) and construct validity (see Bender et al., 2011).

2.3.2. Acquired Capability for Suicide Scale (ACS questionnaire; Van Orden et al., 2008)

The ACS questionnaire is a 20-item measure that assesses fearlessness about lethal self-injury. Individuals rate themselves on each item on a 1 (*not at all like me*) to 5 (*very much like me*) scale (e.g., "The fact that I am going to die does not scare me"; "I could kill myself if I wanted to"). Van Orden et al. (2008) employed a 5-item version of this scale, but Study 1 of Bender et al. (2011) used the same version as the present study. The ACS questionnaire demonstrates good discriminant and convergent validity (Van Orden et al., 2008; Bender et al., 2011). To test the possibility that the ACS questionnaire item "I can tolerate a lot more pain than most people" primarily accounts for associations between this measure and laboratory measures of pain, we also calculated ACS questionnaire scores without this item.

2.3.3. Functional Assessment of Self-Mutilation (FASM; Lloyd-Richardson, 2008)

The FASM is a 33-item measure that assesses type, frequency, and functions of NSSI over the last year (e.g., "[Have you ever] cut or carved your skin"; "[did you do this] to feel relaxed"). Although the FASM also asks about such behaviors as lip-biting and wound-picking, only participants endorsing severe NSSI behaviors such as skin cutting, burning, or scraping were scored as having a history of NSSI (cf. Franklin et al., 2010).

2.4. Experimental tasks

2.4.1. The cold pressor task

The cold pressor task is one of the most widely used forms of experimental pain induction in psychological studies (e.g., Bohus et al., 2000). For this task, next to the participant, we placed a cooler containing a 2 °C (as indexed by a thermometer) mixture of crushed ice and water. We placed a water circulator in the cooler to prevent the water near the participant's hand from warming up. We then instructed the participant to submerge their hand (up to the wrist) in the water. Hand order alternated across participants, with half of the participants submerging their dominant and half submerging their non-dominant hand. Analyses indicated that hand laterality did not influence pain variables ($Ps > 0.05$). The water in the present study was colder than the 10 °C water used in studies examining the association between self-injury and pain (e.g., Bohus et al., 2000). We used colder water to provide a better simulation of the type of intense, acute pain that one might experience during self-injury.

Following the methods of previous studies (e.g., Klatzkin et al., 2010), we employed the cold pressor task to investigate pain threshold, tolerance, and perceived intensity. Specifically, we instructed participants to inform the researcher of two things: (1) when he/she first felt pain and (2) when the pain became intolerable. Pain threshold was quantified as the time elapsed from hand submersion to when the participant indicated that they first felt pain. Pain tolerance was quantified as the time elapsed from hand submersion until participants pulled their hand out of the water, indicating that they could no longer withstand the pain. Elapsed time was measured with two stopwatches: one measured pain threshold and the other measured pain tolerance (researchers later recorded the values on these stopwatches). Timers were activated as soon as participants submerged their hand. At both the pain threshold and tolerance points, we instructed participants to announce the painfulness of the water on a scale of one to ten, with "one" indicating barely perceptible pain and "ten" indicating the most intense pain imaginable. A researcher in an adjacent room then recorded these pain intensity values. Participants were allowed to pull their hand out of the water whenever they desired, and were allowed to keep their hand in the water for a maximum of 2 min. We employed this 2 min limit to reduce outliers. Pilot data indicated that participants rarely reached 2 min; however, when they did, they would often continue indefinitely because of a numbed hand.

2.5. Data analytic plan

First, we calculated the descriptive statistics of all variables. Second, we analyzed the zero-order correlations among all variables. Third, we conducted a multiple mediation analyses with bootstrapping, following the recommendations, models, and methods described by Preacher and Hayes (2008). We employed bootstrapping because, compared to other mediation methods, simulations have shown that it is more powerful, more effective and valid for small sample sizes (e.g., Ns of 20), and less vulnerable to Type 1 error (see Preacher and Hayes, 2008). The multiple mediation bootstrapping technique allows for a test of the individual effects of all proposed mediators. Additionally, it controls for collinearity among variables and mediation effects, meaning that significant mediation effects are all unique effects. For all mediational analyses, gender, NSSI, and subjective units of distress after the speech task were included as covariates.

In Fig. 3, we provide the model employed to test the hypothesis that the PPE–ACS association is partially accounted for by pain tolerance, but not other pain variables. Similar to the basic idea of traditional mediation methods, "A" paths represent the association between PPEs and mediator variables. The "B" paths represent the association between mediator variables and the ACS after controlling for "A." The "C" path represents the total effect of PPEs on the ACS, and the "C'" path represents "C" after controlling for indirect effects (i.e., mediation effects). Indirect effects are defined as A × B. Using the SPSS scripts provided by Preacher and Hayes (2010), we tested these models using both multiple regression (to calculate statistics for specific paths) and bootstrapping (to generate a confidence interval for the mediation effects). These analyses yielded significance tests of specific paths and confidence intervals for mediation effects. We repeated this process with a modified version of the ACS questionnaire to test the possibility that the item "I can tolerate a lot more pain than most people" affects the above analysis.

3. Results

3.1. Descriptive statistics

Descriptive statistics are presented in Table 1. Because previous studies have employed a shortened and altered version of the PPE scale, comparisons with these studies are difficult to make; however, ACS scale scores were similar to those of Bender et al. (2011). Pain threshold, tolerance, and intensity ratings are comparable to those observed in other cold pressor studies (e.g., Klatzkin et al., 2010), but it should be noted that most other studies have employed warmer water, resulting in greater elapsed time for pain threshold and tolerance. In using colder 2 °C water to better approximate the acute, intense pain of suicidality, we obtained proportionally lower threshold and tolerance averages.

3.2. Zero-order correlations

Zero-order correlations were generally consistent with hypotheses (see Table 1). The positive correlation between PPE and ACS measures was nearly identical to the correlation obtained in the nonclinical sample of Bender et al. (2011). Interestingly, this correlation was just as strong when the pain tolerance item from the ACS questionnaire was removed. Pain threshold and tolerance were also significantly positively correlated, and all variables were generally negatively correlated with pain intensity ratings. Importantly, pain tolerance was significantly associated with both PPEs and ACS. Despite using different pain induction methods (cold pressor pain versus pressure pain), these correlations were similar to those of Bender et al. (2011). The PPE scale was only correlated with pain tolerance, but ACS scores were additionally significantly correlated with pain threshold and

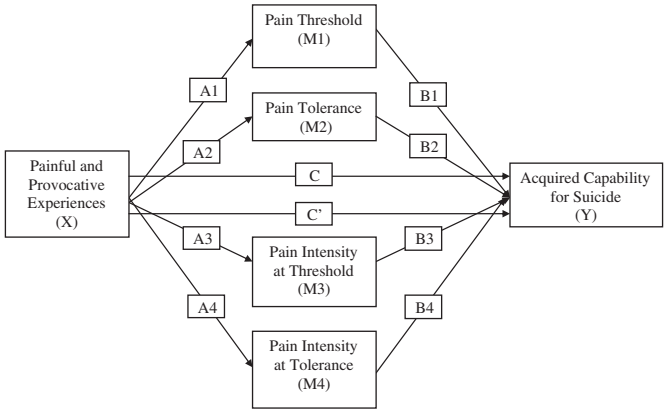

Fig. 3. Multiple mediation model for the hypothesis that pain variables mediate the association between painful and provocative experiences and the acquired capability for suicide.

Table 1
Zero-order correlations and descriptive statistics for suicidality and pain variables.

Variable	1	2	3	4	5	6	7	8
1. PPEs	–	–	–	–	–	–	–	–
2. ACS	0.43***	–	–	–	–	–	–	–
3. ACS minus 1	0.44***	0.99***	–	–	–	–	–	–
4. ACS item 4	0.21*	0.60***	0.54***	–	–	–	–	–
5. Pain threshold	0.08	0.22*	0.28*	0.28*	–	–	–	–
6. Pain tolerance	0.31**	0.40***	0.40***	0.50***	0.22*	–	–	–
7. Intensity at threshold	−0.18	−0.18	−0.16	−0.15	−0.03	−0.46***	–	–
8. Intensity at tolerance	−0.10	−0.27*	−0.27*	−0.40****	−0.25	−0.42***	0.69***	–
Mean	39.01	58.30	55.03	2.88	9.65	40.60	5.10	7.94
SD	6.69	11.65	10.55	1.33	5.49	28.63	1.65	1.67

Notes. PPEs = Painful and Provocative Experiences; ACS = Acquired Capability for Suicide Scale; ACS Minus 1 = the ACS scale without Item 4; ACS Item 4 = "I can tolerate a lot more pain than most people"; Pain threshold and tolerance was calculated in terms of seconds elapsed; Pain intensity was calculated on a 1–10 scale. * = $p<0.05$; ** = $p<0.01$; *** = $p<0.001$.

pain intensity at the tolerance point. Although the ACS scale pain tolerance item was strongly correlated with multiple pain variables, the removal of this item did not substantially reduce correlations between the ACS scale and pain variables.

3.3. NSSI, suicidality, and pain

The effects of NSSI on suicidality and pain variables are shown in Table 2. Although NSSI participants did not endorse significantly more PPEs, consistent with theoretical predictions (Joiner, 2005; Van Orden et al., 2010), NSSI displayed the characteristics of a PPE: it was associated with higher ACS scores and decreased pain perception.

3.4. Multiple mediation analyses

3.4.1. Model with the full ACS scale

Regression analyses showed that the PPE scale only significantly predicted pain tolerance, and that only pain tolerance even displayed a nonsignificant trend for the prediction of ACS scores after controlling for "A" paths (see Table 3). Analyses also revealed that the total and indirect effects were significant (see Table 3), indicating that the combined effect of the mediators mediated the effect of PPEs on ACS, but only partially.

Consistent with predictions, bootstrapping analyses showed that only pain tolerance emerged as a significant mediator of the association between PPEs and ACS (see Table 4). Specifically, analyses indicated that for every one unit increase in PPEs, pain tolerance mediated a 0.13 (95% CI: 0.03 to 0.43) unit increase in ACS. This is a relatively modest statistical effect, though it remains theoretically and clinically important. Nonetheless, it suggests that there are other important mediators of this association.

Table 2
Differences in suicidality and pain variables between NSSI and non-NSSI participants.

Variable	NSSI Participants	Non-NSSI Participants	*t*-value
	Mean (SD)	Mean (SD)	
PPEs	40.62 (4.87)	38.51 (7.13)	1.11
ACS	63.69 (10.06)	56.61(11.69)	2.18*
ACS Minus 1	59.80 (8.45)	54.92 (10.92)	1.83*
ACS Item 4	3.53 (0.74)	2.69 (1.41)	2.23*
Pain threshold	12.07 (7.01)	8.91 (4.78)	2.00*
Pain tolerance	50.28 (32.05)	37.69 (26.81)	1.56^
Intensity at threshold	4.63 (1.59)	5.24 (1.66)	1.30^
Intensity at tolerance	7.13 (1.71)	8.20 (1.59)	2.31*

Notes. PPEs = Painful and Provocative Experiences; ACS = Acquired Capability for Suicide Scale; ACS Minus 1 = the ACS scale without Item 4; ACS Item 4 = "I can tolerate a lot more pain than most people"; Pain threshold and tolerance are calculated in terms of seconds elapsed; Pain intensity is calculated on a 1–10 scale; NSSI = Nonsuicidal Self-Injury (NSSI Group $n=16$; non-NSSI Group n = 51); ^$p<0.10$; *$p<0.05$.

3.4.2. Model without the ACS Scale Pain Tolerance Item

Results were nearly identical to the previous model. Pathways from the PPE scale to mediators ("A" paths) were the same as those in the previous model. For "B" paths, there were no significant pathways from mediators to the modified ACS scale while controlling for "A" paths, although the pathway from pain tolerance was trending ($P<0.10$). In terms of mediation, direct ($B=0.65$, $SE=0.21$, $t=3.12$, $P<0.01$) and indirect ($B=0.53$, $SE=0.21$, $t=2.52$, $P<0.05$) effects were both significant, indicating that pain variables partially mediated the association between the PPE scale and the modified ACS scale. Bootstrapping results indicated that only pain tolerance significantly mediated the association between the PPE scale and the modified ACS scale ($B=0.11$, $SE=0.08$; 95% CI: 0.02 to 0.39). Removing the pain tolerance item did not substantially reduce the degree to which pain tolerance accounts for the PPE–ACS association ($B=0.13$ when this item was included).

4. Discussion

The purpose of the present study was to clarify the role of pain tolerance in suicidal capability. Overall, results were highly consistent with the predictions of the interpersonal-psychological theory of suicide (Joiner, 2005; Van Orden et al., 2010). Individual findings are discussed in detail below.

Consistent with Bender et al. (2011), results showed that pain tolerance was significantly correlated with self-report measures of PPEs and ACS (see Table 1). Building on Bender et al.'s (2011) findings with pressure-based pain, we replicated these effects with the cold-based pain. Results also supported the hypothesis that NSSI is a PPE.

Table 3
Regression results for paths in the multiple mediation model for the IPTS hypothesis.

Path	Beta (SE)	*t*-Value
PPEs to mediators ("A" paths)		
Pain threshold	0.12 (0.12)	1.03
Pain tolerance	1.30 (0.62)	2.11*
Intensity at threshold	−0.04 (0.04)	−1.11
Intensity at tolerance	−0.02 (0.04)	−0.52
Mediators to ACS ("B" paths)		
Pain threshold	0.13 (0.26)	0.50
Pain tolerance	0.10 (0.05)	1.90^
Intensity at threshold	0.75 (1.14)	0.66
Intensity at tolerance	−1.05 (1.14)	−0.92
Effect of PPEs on ACS ("C" paths)		
Total effect (c)	0.73 (0.23)	3.23***
Direct effect (c`)	0.59 (0.23)	2.57**

Notes. PPEs = Painful and provocative experiences; ACS = Acquired capability for suicide; ^$p<0.10$; *$p<0.05$; **$p<0.01$; ***$p<0.001$; gender, NSSI history, and subjective units of stress before engaging in the cold pressor task were both covariates in these analyses (analyses without these covariates yielded essentially the same results).

Table 4
Bootstrapping of indirect effects in the multiple mediation model.

Proposed mediators (A*B paths)	Beta (SE)	BCa 95% CI	
		Lower	Upper
Pain threshold	0.02 (0.04)	−0.02	0.18
Pain tolerance	0.13 (0.08)	0.03	0.43*
Intensity at threshold	−0.03 (0.07)	−0.26	0.04
Intensity at tolerance	0.02 (0.05)	−0.03	0.25

Notes. * = 95% CI did not include 0, indicating that this effect is significantly different from 0. BCa = Bias Corrected and Accelerated, as recommended by Preacher and Hayes (2008) to reduce bias in bootstrapping analyses. Data were resampled 5000 times, as recommended by Preacher and Hayes (2008). Gender, NSSI history, and subjective units of stress before engaging in the cold pressor task were both covariates in these analyses (analyses without these covariates yielded essentially the same results).

Similar to associations with more general PPEs (see Table 1), NSSI was associated with increased ACS and decreased pain perception (see Table 2). Although previous studies have demonstrated that NSSI is associated with decreased pain perception and an increased risk of suicide (Andover and Gibb, 2010; Hooley et al., 2010), the present results represent the first empirical evidence that NSSI is associated with a direct measure of ACS.

Analyses demonstrated that pain tolerance accounts for variance within the PPE–ACS association. This falsifies the alternative model of suicidal capability (see Fig. 2) and provides further support for the interpersonal-psychological theory of suicide (see Fig. 1). Results also supported the hypothesis that pain tolerance is the most important pain variable within the PPE–ACS relationship. Although ACS was correlated with pain threshold, tolerance, and intensity ratings at the tolerance point (see Table 1), only pain tolerance significantly accounted for variance within the PPE–ACS association when all pain variables were entered into a multiple mediation model. This provides important discriminant validity for the interpersonal-psychological account of suicidal capability (see Fig. 1). Surprisingly, these results held up when the item "I can tolerate a lot more pain than most people" was removed from the ACS scale. This was even more surprising considering that this item was correlated with PPEs and several pain variables (see Table 1). This indicates that that pain tolerance is an important component of the general ACS construct (cf. Joiner, 2005; Van Orden et al., 2010) rather than an artifact of the pain tolerance item on the ACS scale. This finding also highlights the importance of including both self-report and behavioral measures, and suggests that the interpersonal-psychological theory of suicide may benefit from separately considering perceived and actual pain tolerance.

It should be noted, however, that the PPE–ACS association remained significant after controlling for pain variables (see Table 3) and the mediation effect was relatively modest. This suggests that other factors also play an important role in this relationship. As reviewed by Van Orden et al. (2010), perhaps the most likely candidate is lowered fear of death. Pain tolerance is a general variable whereas fear of death is a relatively suicide-specific variable. Thus, changes in fear of death may more specifically and effectively explain the association between PPEs and ACS.

The present findings should be interpreted in accord with their limitations. First, although the PPE–ACS association should exist – perhaps even more strongly – in nonclinical populations (cf. Van Orden et al., 2010; Bender et al., 2011), future studies should utilize clinical samples. Similarly, although the present sample size and multiple mediation model with bootstrapping allowed for the detection of small to moderate effects, future studies should employ larger samples to permit the detection of smaller effects.

Second, the present study was conducted in the context of a larger psychophysiological study that induced stress before the cold pressor task and included some individuals who engaged in NSSI. To control for these factors we included NSSI history and subjective units of stress after the speech task as covariates in mediational analyses, and we note that results were essentially the same (i.e., the same variables reached significance) in analyses that did not include these covariates. Nonetheless, these factors may still limit the generalization of the present results. Indeed, possibly due in part to these factors, gender differences in pain threshold and tolerance were much smaller than in other studies (e.g., Klatzkin et al., 2010). Future studies should seek to replicate the present findings in other contexts.

Third, different experimental assessments of pain (e.g., heat pain, ischemic pain, and pressure pain) are generally highly correlated (e.g., Klatzkin et al., 2010), but future studies should examine suicidal capability with other pain measures. There are necessarily limitations to approximating the pain involved in actual self-injury and it is unclear how well the cold pressor task does this; nevertheless, it is notable that the present results were highly consistent results from a study that employed a very different kind of pain—pressure pain (Bender et al., 2011). Fourth, we employed relatively cold water in the cold pressor task in an effort to better model the acute, intense pain associated with self-injury; however, this likely restricted the ranges of our pain variables and may restrict the generalizability of results.

Fifth, although we employed a multiple mediation technique, the present study was cross-sectional and accordingly cannot speak to any temporal or causal associations. The present results are consistent with the causal model described by Joiner (2005); nonetheless, this suggestive cross-sectional data must be validated by longitudinal data before any temporal conclusions may be drawn. Finally, the PPE and ACS measures employed in this study were developed specifically to index these components of the interpersonal-psychological theory of suicide, but future studies may benefit from obtaining multiple measures of these constructs (preferably a combination of self-report, implicit, and physiological measures).

In sum, the present study clarifies the role of pain tolerance in suicidality capability in several ways. Consistent with the interpersonal-psychological theory of suicide (Joiner, 2005; Van Orden et al., 2010), however, the present results also suggest that factors other than pain tolerance are important to the PPE–ACS association. Future studies should build on the present results to investigate the role of factors such as fear of death.

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