

Social Problem-Solving and Suicidal Behavior in Adolescent Girls: A Prospective Examination of Proximal and Distal Social Stress-Related Risk Factors

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Adverse social experiences are often linked to suicidal behavior in adolescence, perhaps particularly for girls. Social problem-solving abilities may indicate more or less adaptive responses to adverse social experiences that contribute to adolescent girls' risk for suicidal behavior. While social problem-solving is implicated in cognitive and behavioral theories of suicidal behavior, prior work is largely cross-sectional and examines bivariate associations between social problem-solving, assessed in neutral conditions, and suicidal behavior. Using a novel performance-based task, this study assessed social problem-solving in adolescent girls ($N = 185$, $M_{\text{age}} = 14.66$, $SD = 1.41$) before and after an experimentally simulated social stressor and examined associations between social problem-solving and past-year suicidal behavior. Prospective analyses tested whether greater changes in specific social problem-solving domains following the social stressor predicted greater likelihood of suicidal behavior over a 9-month follow-up in contexts of elevated, real-life interpersonal stress. Results revealed that adolescent girls who showed greater changes (i.e., reflecting declines) in problem-solving effectiveness following acute social stress were more likely to exhibit suicidal behavior over the following 9 months, but only if they also experienced elevated interpersonal stress in real life. State-dependent changes in social problem-solving may indicate a cognitive vulnerability following social stress that, in combination with cumulative interpersonal stress in real life, distinguishes adolescent girls at heightened risk for future suicidal behavior. Findings demonstrate the importance of examining suicide risk factors under conditions that may more closely mirror the interpersonal contexts in which adolescents' risk for suicidal behavior may be elevated.

General Scientific Summary

Suicide is the second leading cause of death among adolescents, and rates of suicide attempts are particularly high among adolescent girls. This study suggests that deficits in social problem-solving, particularly in problem-solving effectiveness, in contexts of elevated, real-life interpersonal stress may distinguish adolescent girls at greater risk for future suicidal behavior. Findings highlight the importance of studying state-dependent changes in suicide risk factors under conditions that may more closely mirror the interpersonal contexts in which adolescents' risk for suicidal behavior may be heightened.

Keywords: social problem-solving, suicide, life stress, interpersonal, adolescents

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This research was supported by a NIMH grant to Matthew K. Nock and Mitch J. Prinstein (R01MH085505). Approval was obtained from The University of North Carolina Institutional Review Board (#07-0929). Informed assent/consent was obtained from adolescent participants and their parent(s)/guardian(s). The authors report no relevant conflicts of interest. Materials are available from the authors upon request.

Olivia H. Pollak served as the lead for conceptualization, formal analysis, and writing—original draft and served in a supporting role for methodology. Shayna M. Cheek served in a supporting role for conceptualization. Karen D. Rudolph served in a supporting role for methodology,

resources, supervision, and writing—review and editing. Paul D. Hastings served in a supporting role for methodology and resources. Matthew K. Nock served as the lead for funding acquisition and served in a supporting role for conceptualization, methodology, and resources. Mitch J. Prinstein served as the lead for funding acquisition, investigation, methodology, project administration, resources, and supervision and served in a supporting role for conceptualization and writing—review and editing.

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Suicide is a leading cause of death among adolescents (Centers for Disease Control and Prevention, 2019). Adolescent girls may be at particularly high risk: more than one in 10 girls reported attempting suicide in 2021, with adolescent girls almost twice as likely to attempt suicide compared to boys (Centers for Disease Control and Prevention, 2023). Rates of suicide attempts among girls have risen nearly 30% in the past decade—a nearly two-fold sharper increase than among boys (Centers for Disease Control and Prevention, 2023). Despite these data, few studies have examined female adolescent samples to better understand which girls may be most likely to engage in suicidal behavior in this period.

Developmentally centered suicide theories posit that normative social changes in adolescence (e.g., peer network reorganization) may interact with developmental maturation (e.g., physiological stress reactivity) to increase suicide risk in this period (Miller & Prinstein, 2019). These explanations may be especially pertinent to adolescent girls, who are exposed to greater peer group stress and are more likely to exhibit internalizing reactions to social stress compared to adolescent boys (Rose & Rudolph, 2006; Slavich et al., 2020). Although most adolescents experience, and are affected by, social stress, only a minority engage in suicidal behaviors. There is a need to further examine particular responses to social stress that may explain for which adolescent girls social stress exposure may be linked to suicidal behavior.

Individual differences in cognitive processes may help to explain which adolescents process and respond to social stress in ways that increase their vulnerability to suicidal behavior. Maladaptive cognitive responses to distress are implicated in several forms of psychopathology (e.g., ruminative response styles in depression; Nolen-Hoeksema et al., 2008), but remain understudied in relation to suicidal outcomes (Cha et al., 2019). There has been particularly little work examining cognitive risk factors for suicidal behavior (Franklin et al., 2017), as well as social-contextual moderators (Wenzel & Beck, 2008). Although some studies show associations between suicidal behavior and certain cognitive tendencies in interpersonal contexts (e.g., negative feedback-seeking; Stellrecht et al., 2006), they largely examine trait-level cognitive risk factors, which may not reflect cognitive processes under distress. Prospective studies of these cognitive vulnerabilities—specifically, those related to adverse interpersonal experiences—are also lacking (Cheek et al., 2020).

Cognitive processes that underlie behavioral competencies under distress may be promising risk factor candidates for suicidal behavior. In particular, problem-solving—the ability to consider or enact adaptive solutions to problems—is a critical component of several theoretical pathways linking experiences of stress with suicidal outcomes, including suicidal behavior. Problem-solving is implicitly central to many suicide theories (e.g., Joiner, 2005; Klonsky & May, 2015; O'Connor, 2011) given its overlap with constructs, like hopelessness and future thinking, that encompass similar cognitive processes (e.g., attitudes toward oneself or others; self-efficacy to achieve goals or engage in desired behaviors; Cxyz et al., 2016; Millner et al., 2020). Cognitive and dialectical behavioral theories of suicidal behavior more specifically posit that distress following stress exposure may result in reduced problem-solving abilities, which may potentiate adverse reactions to future social stressors and increase suicidal behavior risk (Liu & Spirito, 2019; Spirito et al., 2012)—possibly by reducing the set of adaptive behaviors available to an individual in response to acute stressors (Rotheram-Borus et al., 1990). Problem-solving deficits may also encompass

maladaptive cognitive responses to problems, such as self-blame and low self-efficacy to enact adaptive solutions. Under stress, this may increase risk for suicidal behaviors as alternative “solutions” that may be congruent with negative, self-focused cognitions (e.g., low self-efficacy, defeat, entrapment; Cha et al., 2019; O'Connor et al., 2013) or more easily accessible than adaptive behaviors requiring engagement with others or pursuit of social or other support (Thompson et al., 2002).

Individuals with histories of suicidal ideation or behaviors show deficits in multiple problem-solving domains, although prior studies are largely adult-based (Orbach et al., 1990; Pollock & Williams, 1998, 2001; Williams et al., 2005). Among adolescents, there is modest, cross-sectional support for problem-solving deficits among youth who have attempted suicide, compared to psychiatric and nonpsychiatric controls (for a review, see Speckens & Hawton, 2005). However, studies in youth (Platt et al., 1974; Sadowski & Kelley, 1993; Schotte & Clum, 1987) use a variety of problem-solving measures and inconsistent suicide outcome variables, making it difficult to discern clear patterns across prior literature. Notably, few studies of problem-solving have examined suicidal behavior (vs. ideation only, or ideation or behavior) prospectively, despite evidence that social problem-solving deficits may precede engagement in risk behaviors (Crick & Dodge, 1994; Dubow & Tisak, 1989) and cross-sectional associations with other self-injurious behaviors in adolescents (i.e., nonsuicidal self-injury; Nock & Mendes, 2008).

Given that adolescence is marked by increases in rates of suicidal behavior and sensitivity to adverse peer experiences (Somerville, 2013), *social* problem-solving may be particularly relevant to risk during this period. Poor *social problem-solving*, in response to interpersonal problems, may further increase the potentially deleterious impact of the social stressors that are among the strongest risk factors for adolescents' suicidal behavior (King & Merchant, 2008; Pettit et al., 2011). Social problem-solving domains capturing dimensions of *solution enactment* (vs. solution generation or quality) may also be particularly pertinent to suicidal behavior. In prior work, adolescents with suicide attempt histories generated as many adaptive solutions to interpersonal problems as controls but provided less accurate problem-solving appraisals and reported using fewer strategies, suggesting that suicidal behavior may be associated more specifically with deficits in solution enactment (Wilson et al., 1995). Domains such as problem-solving *self-efficacy* (i.e., confidence in one's ability to carry out a desired behavior) and *effectiveness* (i.e., ability to carry out a behavior) may be closely linked to problem outcomes. Self-efficacy beliefs about the feasibility or likelihood of performing goal-directed behaviors may inhibit or facilitate adaptive behavioral responses in social contexts (Bandura, 1977; Crick & Dodge, 1994), while effectiveness may facilitate solution implementation (Gollwitzer & Sheeran, 2006). Deficits in these domains may potentiate adverse consequences of interpersonal problems and increase the risk for suicidal behavior. Indeed, lower self-efficacy to engage in coping (i.e., problem-solving) strategies and differences in effective use of active or problem-focused coping have been shown to predict future suicidal behavior risk in adolescents (Cxyz et al., 2016; Horwitz et al., 2018).

Problem-solving self-efficacy and effectiveness may also be important contributors to outcomes in adolescent girls. Sex differences in social-cognitive styles indicate that adolescent boys may be more likely to focus on agentic goals, whereas girls' relational-orientation style may be better characterized by connection-oriented

goals (Rose & Rudolph, 2006). This latter style may be related to greater social-evaluative concerns and emotional distress concerning relationships or social conflict, perhaps particularly in combination with low self-efficacy (Rudolph & Conley, 2005). Girls also experience greater interpersonal stress in adolescence, and girls' emotional functioning is more directly tied to concerns about social relationships compared to boys (Hankin et al., 2007; Rose & Rudolph, 2006). Adolescent girls¹ who show deficits in social problem-solving self-efficacy or effectiveness may experience adverse reactions to future interpersonal stress and be at greater risk for suicidal behavior.

Additionally, prior work has most often assessed problem-solving in neutral conditions, typically using self-report, which may be more likely to capture subjective appraisals of a trait-level construct. Although problem-solving deficits may characterize suicidal adolescents across contexts, deficits may emerge or worsen under state-dependent conditions of distress (Schotte et al., 1990). Certain cognitive risk factors for suicide may distinguish suicidal individuals only under distress-related conditions (e.g., negative mood; Cha et al., 2018), and a prior study found that suicidal adults with a history of depression showed problem-solving declines following a negative mood induction (Williams et al., 2005). This effect was not observed among formerly depressed but nonsuicidal individuals—suggesting that distress-related problem-solving deficits may be associated with suicide-related outcomes above and beyond potential covariates such as depressive symptoms. Sensitivity to internal states may also characterize decision-making in suicidal behavior (Dombrowski & Hallquist, 2017), further suggesting the importance of state-dependent problem-solving.

Finally, in line with life-stress and stress-generation models of psychopathology and suicidal behavior (Liu & Spirito, 2019; Rudolph et al., 2000), social problem-solving deficits may confer the greatest risk for suicidal behavior in contexts of cumulative, real-life interpersonal stress. Among young adults with poor social problem-solving, those who reported higher levels of negative life stress also endorsed more severe suicidal ideation (Schotte & Clum, 1982). Interpersonal stress (i.e., stressors whose impacts may be mitigated or exacerbated by social problem-solving abilities) may be particularly deleterious, while noninterpersonal stress (i.e., stressors whose impacts may be more independent of one's interpersonal behaviors or skills) may be less relevant to this risk pathway. Longitudinal approaches are needed testing interactions between state-dependent social problem-solving (i.e., following interpersonal stress) and actual experiences of cumulative interpersonal stress. The use of objective measures, such as behavioral problem-solving tasks and contextual life stress interviews, also may offer improved validity over self-report.

To address these gaps, this investigation examined associations between adolescent girls' social problem-solving (i.e., problem-solving *self-efficacy* and *effectiveness*) and suicidal behavior in contexts of both proximal (i.e., lab-based) and more distal (i.e., naturally occurring) interpersonal stress. Study methods offered several advantages over prior work. First, a performance-based problem-solving task was administered following acute social stress to assess state-dependent social problem-solving under conditions that may mirror adolescents' real-world experiences of interpersonal stress. Second, analyses examined distress-related *changes* in problem-solving. Intraindividual changes in risk factors (i.e., relative to a person's baseline or average) may be robust predictors of

suicidal outcomes (Miller et al., 2017) and, for certain risk factors, may be stronger predictors of suicidal behavior than baseline or mean levels (Wang et al., 2021). Finally, this investigation considers adolescents' real-world experiences by examining whether state-dependent problem-solving deficits are associated with future suicidal behavior specifically in contexts of cumulative interpersonal, but not noninterpersonal, stress in real life.

Cross-sectional analyses first examined differences in problem-solving based on the history of suicidal behavior and exposure to acute social stress. We hypothesized that adolescent girls with a history of suicidal behavior would exhibit deficits in problem-solving before acute social stress and greater declines in problem-solving following acute stress, relative to adolescents without histories of suicidal behavior. The primary aim was longitudinal and tested the hypothesis that problem-solving deficits would be associated with greater risk for future suicidal behavior in contexts of elevated, real-life interpersonal stress.

Method

Participants

Participants were clinically referred adolescent females (i.e., biological sex at birth), ages 12–17, recruited from inpatient and outpatient facilities, and who endorsed mental health concerns (e.g., mood disorders, substance use) in the prior 2 years. A clinical sample spanning early to middle adolescence was selected to overlap with the onset of puberty, given the hypothesized links between puberty-related changes in social functioning and social stress reactivity, and suicidal behavior risk in adolescence (Miller & Prinstein, 2019). Of the 187 adolescents with social problem-solving data at baseline, two were excluded from analyses due to lack of past-year suicidal behavior data at baseline. The final sample included 185 adolescents ($M_{\text{age}} = 14.66$, $SD = 1.41$) and was majority (62.7%) White (24.9% African American; 9.7% mixed/other; 1.1% Asian; 1.6% Latina).

Measures

Suicidal Behavior

Suicidal behavior was assessed using the Self-Injurious Thoughts and Behaviors Interview (SITBI; Nock et al., 2007), a semi-structured interview assessing the presence, frequency, and characteristics of self-injurious thoughts and behaviors across various time periods. At baseline, questions assessed the past-year presence of multiple types of suicidal behaviors: suicide plan, interrupted suicide attempt, aborted suicide attempt, and suicide attempt. At each follow-up, questions assessed the presence of these same suicidal behaviors in the prior 3 months. Composite suicidal behavior variables were created to capture the presence of at least one of these types of suicidal behavior(s) for baseline (i.e., capturing presence in the past year) and over follow-up (i.e., capturing presence over the 9-month follow-up period). The SITBI yields good reliability

¹ While the present study focused on adolescent females (i.e., biological sex at birth), other aspects of gender identity may also impact youths' cognitive or behavioral responses to interpersonal stressors in ways that increase the risk for engagement in maladaptive behaviors, such as suicidal behavior (Fox, Millner et al., 2018; Smith et al., 2020).

and agreement with other suicide measures in adolescents (Nock et al., 2007).

Social Problem-Solving

Social problem-solving was measured using a novel performance-based task called the Social Problem-Solving Skills Test (SPST; Nock & Mendes, 2008), administered by undergraduate research assistants acting as interviewers. Adolescents first listened to audio recordings of hypothetical social scenarios involving problems with peers, friends, a romantic partner, parent, and teacher. Following each scenario, participants performed problem-solving tasks as prompted by the interviewer following a standardized administration manual, including rating and enacting potential problem solutions (e.g., initiating a conversation with a romantic partner about a hurtful comment). The SPST assessed multiple problem-solving domains with both participant self-report items (i.e., *self-efficacy*) and objective ratings (i.e., *effectiveness*) of behavioral performance assigned by an independent team of coders using a manualized coding system. Coders were "masked" as to whether the problem-solving task being coded had come before or after the Trier Social Stress Test (TSST). This investigation focused on problem-solving *self-efficacy* and *effectiveness*. For *self-efficacy*, participants were provided with one solution that would likely lead to a positive outcome and rated their perceived ability to use that solution to solve the problem (0 = *low*, 4 = *high*). For *effectiveness*, participants were instructed to pretend the other person(s) involved in the scenario was sitting across from them and to say or do what they would do to successfully cause a positive outcome. Participants enacted this for up to 30 s while audiotaped. Problem-solving effectiveness was coded as effectiveness of behaviors for positively achieving the solution goal (1 = *low*, 4 = *high*). Participants were administered four SPST scenarios before, and four different SPST scenarios after undergoing an experimental social stressor task (i.e., the TSST). The administration of SPST scenarios before and after the stressor task was counterbalanced across participants. In this sample, the interrater reliability for the SPST constructs examined in this study was good (intraclass correlation coefficient [ICC] = 0.80, $p < .01$).

Acute Social Stress

Acute social stress was simulated using an adaptation of the TSST (Kirschbaum et al., 1993). Participants were given 1 min to prepare, and 3 min to deliver, an impromptu speech (i.e., simulating an audition for a reality TV show about how teens interact with peers) to an imaginary peer audience watching a live video feed. An undergraduate research assistant acting as a confederate entered the room and asked the adolescent participant to deliver her speech while facing a video camera. Participants were unaware that the peer audience was fictional and were told that the confederate would be evaluating their audition. The confederate pretended to evaluate the speech by making marks on a clipboard but refrained from providing feedback except to prompt the participant if she stopped speaking before 3 min elapsed. The TSST has been shown to elicit meaningful stress-related responses in adolescents (e.g., Klimes-Dougan et al., 2001).

Life Stress

Life stress over the 9-month follow-up was assessed using the Youth Life Stress Interview (YLSI; Rudolph & Flynn, 2007),

a semi-structured interview assessing the nature and intensity of participants' experiences of stress across multiple domains (e.g., school, peer relationships, parent-child relationships). Interviewers received extensive training to collect detailed factual information about the timing and contextual features of stressful life events. Expert raters used a consensus process to assign an objective stress rating to each event on a 5-point scale based on how the event would impact a typical adolescent in the same circumstances, with higher scores corresponding to greater stressfulness. Raters also categorized each event as interpersonal (i.e., involving an adolescent's relationship or interaction with another individual) or noninterpersonal. These categorizations were used to calculate interpersonal and noninterpersonal stress severity scores (i.e., two separate scores) for each participant across the three follow-up assessments (at 3, 6, and 9 months), capturing interpersonal stress (i.e., mean score) over the full 9-month follow-up period. Primary analyses focused on stressors within interpersonal domains (e.g., conflict with a friend) and used interpersonal stress scores; sensitivity analyses used noninterpersonal stress scores to examine whether findings generalized to stressors in noninterpersonal domains (e.g., receiving a poor test grade). YLSI coders showed excellent reliability for both life event severity scores (ICC = 0.95) and categorization of interpersonal versus noninterpersonal event content ($\kappa = 0.92$).

Depressive Symptoms

Depressive symptoms were assessed with the Mood and Feelings Questionnaire (MFQ; Costello & Angold, 1988), a 33-item self-report measure assessing depressive symptoms in children and adolescents. Participants rated the extent to which items applied to them in the prior 2 weeks on a 3-point Likert scale (0 = *not true*, 2 = *mostly true*). To avoid concerns about inflated associations, four items assessing suicidal ideation were removed (e.g., "I thought about killing myself"). All other items were averaged to yield a mean score, with higher scores indicating more severe depressive symptoms. Participants completed the MFQ at baseline ($\alpha = 0.94$). Prior work demonstrates strong psychometric properties for the MFQ in adolescent samples (Daviss et al., 2006).

Procedure

Participants attended a baseline lab visit with a caregiver. After parents and adolescents granted consent/assent in accordance with the university's Institutional Review Board, adolescent participants completed self-report measures (i.e., demographics, depressive symptoms), the SITBI (i.e., suicidal behavior), and the SPST (i.e., social problem-solving). Participants then underwent the TSST and completed the SPST again, immediately after the TSST. Following the lab visit, life stress and suicidal behaviors experienced after the lab visit were assessed via phone-based assessments at 3-, 6-, and 9-month intervals to facilitate more accurate reporting (i.e., retrospective reporting across shorter timespans).

Analytic Plan

Regression diagnostics were conducted to check that no single case exerted undue influence on parameter estimates and

that multicollinearity assumptions were met. At the lab visit, minimal data were missing (0.50%–1.60%) and Little's Missing Completely at Random (MCAR) test supported MCAR, $\chi^2(7) = 5.37, p = .62$. Cross-sectional analyses used all available data and examined associations between social problem-solving and past-year suicidal behavior history in the following ways: (a) *t* tests examined baseline versus post-TSST problem-solving across the sample, and baseline differences based on past-year suicidal behavior history; (b) repeated measures analysis of variances examined group differences in changes in problem-solving based on the past-year history of suicidal behavior, with problem-solving variables as the within-subjects factor with two levels (i.e., baseline and post-TSST) and the past-year suicidal behavior group (i.e., presence vs. absence) as the between-subjects factor. Time \times Group interactions were estimated to test the hypothesis that adolescents with (vs. without) past-year suicidal behavior histories would show greater problem-solving declines after acute social stress.

Primary analyses tested prospective associations between changes in social problem-solving and future suicidal behavior. Follow-up data were missing for life stress and suicidal behavior due to attrition (22.7%–30.3%). Consistent with prior longitudinal studies of suicidal behavior (Glenn et al., 2019), prospective analyses used listwise deletion as a conservative approach among adolescents with life stress and suicidal behavior data over follow-up.² Interactions of self-efficacy and effectiveness with interpersonal life stress were hypothesized, such that adolescents who showed greater changes (i.e., reflecting declines) in self-efficacy and effectiveness would be more likely to engage in suicidal behavior over the 9-month follow-up in contexts of higher than lower levels of real-life interpersonal stress. Variables capturing change in problem-solving self-efficacy and effectiveness were computed by subtracting pre-TSST from corresponding post-TSST variables. Two hierarchical logistic regression models were tested predicting suicidal behavior (presence vs. absence) across the 9-month follow-up. Changes in problem-solving self-efficacy and effectiveness were examined as predictors in separate models; interpersonal stress over the 9-month follow-up was tested as a moderator in both. Age, baseline depressive symptoms, and baseline suicidal behavior (i.e., past-year history) were correlated with problem-solving and/or the presence of suicidal behavior over follow-up and included as covariates. To further isolate the unique effects of *change* in problem-solving and control for individual differences in baseline problem-solving on suicidal behavior over follow-up, models also controlled for baseline problem-solving (i.e., pre-TSST self-efficacy and pre-TSST effectiveness) and for their interactions with interpersonal stress. Standardized variables were used to compute interaction terms and in regression analyses. To test the secondary hypothesis that problem-solving would not be associated with suicidal behavior in contexts of elevated *noninterpersonal* life stress, models were repeated with noninterpersonal stress as a moderator.

Transparency and Openness

We report how we determined our sample size, data exclusions, manipulations, and measures. Data were analyzed using SPSS (IBM; v.27). This study was not preregistered. Materials are available from the authors upon request.

Results

Cross-Sectional Group-Level Analyses

Descriptive statistics and correlations among primary variables in cross-sectional analyses are presented in Table 1. In this sample, 65 adolescents endorsed a lifetime history of suicidal behavior at the lab visit, with 55 adolescents endorsing a history of suicidal behavior in the past year (55 endorsed a suicide plan and 37 endorsed a suicide attempt in the past year). Across the sample, there was a significant decline in problem-solving self-efficacy, $t(181) = 3.31, p = .001, d = 0.25$, following the TSST, but no significant change in problem-solving effectiveness, $t(181) = -0.79, p = .43, d = 0.06$. At baseline, adolescents with past-year suicidal behavior histories had significantly lower self-efficacy than adolescents without past-year suicidal behavior histories, $t(183) = 2.20, p = .03, d = 0.35$. There was no group difference in effectiveness at baseline, $t(183) = -0.51, p = .61, d = 0.08$.

When testing changes in problem-solving by suicidal behavior history group, the Time \times Group interaction was significant for self-efficacy, $F(1, 180) = 5.18, p = .02, \eta_p^2 = .03$, but not effectiveness, $F(1, 180) = 0.73, p = .39, \eta_p^2 = .004$. Post hoc tests with Bonferroni correction revealed that adolescents without past-year suicidal behavior histories showed significant declines in self-efficacy, $p < .001$, while there was no significant change in self-efficacy among adolescents with past-year suicidal behavior histories, $p = .94$. The Time \times Group interaction was not significant in sensitivity analyses controlling for depressive symptoms, $F(1, 178) = 2.44, p = .12, \eta_p^2 = .01$.

Prospective Associations Among Social Problem-Solving, Interpersonal Stress, and Suicidal Behavior

In the sample examined in prospective analyses, 19 adolescents endorsed suicidal behavior across the full 9-month follow-up period, among whom 57.9% had endorsed a past-year history of suicidal behavior at baseline. Past-year history of suicidal behavior at baseline was associated with the presence of suicidal behavior across follow-up, $\chi^2(1) = 19.56, p < .001$. At 3-month follow-up, seven adolescents endorsed a suicide plan and four endorsed a suicide attempt in the prior 3 months. At the 6-month assessment, four adolescents endorsed a suicide plan and four endorsed a suicide attempt in the prior 3 months. At the 9-month assessment, five adolescents endorsed a suicide plan and two endorsed a suicide attempt in the prior 3 months.

There was a significant interaction of change in problem-solving effectiveness with interpersonal stress over the 9-month follow-up

² Little's MCAR test supported MCAR, $\chi^2(29) = 34.44, p = .22$, for prospective analyses. Problem-solving variables were not associated with the likelihood of missing 9-month life stress and/or suicidal behavior data (ORs = 0.75–1.10, $ps = .13$ –.97). Among covariates, only past-year suicidal behavior history was associated with the missingness of 9-month life stress ($\chi^2s = 4.95$ –6.64, $ps = .01$ –.03), but not suicidal behavior ($\chi^2s = 0.91, ps = .34$), data. The presence of 9-month suicidal behavior was not associated with the missingness of 9-month life stress data ($\chi^2s = 3.07$ –4.00, $ps = .05$ –.08), and 9-month life stress was not associated with the missingness of 9-month suicidal behavior data (ORs = 0.91–1.21, $ps = .47$ –.69). Participant race/ethnicity was not associated with missingness of 9-month life stress and/or suicidal behavior data ($\chi^2s = 1.30$ –2.97, $ps = .56$ –.86).

Table 1
Descriptive Statistics and Bivariate Correlations Among Problem-Solving Variables and Covariates Examined in Cross-Sectional Analyses

Variable	1	2	3	4	5	6	7
1. Baseline self-efficacy	—						
2. Δ self-efficacy	-0.44**	—					
3. Baseline effectiveness	-0.18*	0.04	—				
4. Δ effectiveness	-0.07	0.12	-0.42**	—			
5. Baseline depressive symptoms (MFQ)	-0.32**	0.14	-0.07	0.09	—		
6. Age	-0.11	0.07	0.11	-0.02	0.19**	—	
7. Past-year SB history at baseline ^a	-0.16*	0.17*	0.04	0.06	0.44**	0.18*	—
<i>M</i>	2.93	-0.17	2.71	0.04	0.50	14.66	—
<i>SD</i>	0.55	0.70	0.62	0.59	0.40	1.41	—

Note. MFQ = Mood and Feelings Questionnaire; SB = suicidal behavior (i.e., suicide plan; interrupted or aborted suicide attempt; and/or suicide attempt); *SD* = standard deviation. Pearson's correlations are presented for all variables except past-year SB history (i.e., point-biserial correlations).

^a Participants with a past-year SB history had lower baseline self-efficacy, less change (i.e., decline) in self-efficacy after acute social stress, greater baseline depressive symptoms, and were older than those without a past-year SB history.

* $p < .05$. ** $p < .01$.

for the prediction of suicidal behavior (odds ratio [*OR*] = 0.36, 95% confidence interval [*CI*] = [0.15–0.87], $p = .02$; Table 2). This interaction was probed at low (-1 *SD*), average (*M*), and high ($+1$ *SD*) levels of interpersonal stress (Figure 1). Adolescents with greater changes (i.e., reflecting declines) in problem-solving effectiveness were more likely to exhibit suicidal behavior over follow-up at high levels of interpersonal stress ($OR = 0.30$, [0.10–0.92], $p = .04$). Change in effectiveness was not associated with future suicidal behavior at average and low levels of interpersonal stress ($ORs = 0.85$ – 2.39 , $ps = .12$ – $.63$). In the self-efficacy model, the interaction of change in self-efficacy with interpersonal stress was not significant ($OR = 0.85$, [0.41–1.77], $p = .67$).

Prospective Associations Among Social Problem-Solving, Noninterpersonal Stress, and Suicidal Behavior

Additional analyses tested the interaction of change in problem-solving effectiveness with noninterpersonal stress over follow-up. In contrast to results for interpersonal stress, the interaction of change in effectiveness with noninterpersonal stress did not predict the likelihood of suicidal behavior over follow-up ($OR = 0.56$, [0.24–1.30], $p = .17$). Similarly, the interaction of change in self-efficacy with noninterpersonal stress was not associated with future suicidal behavior ($OR = 1.21$, [0.67–2.19], $p = .53$).³

Discussion

Problem-solving is implicated in multiple suicide theories, but few studies have examined whether problem-solving deficits, particularly under distress, may help to explain which adolescents later engage in suicidal behavior. Building on evidence that social, including peer-related, stressors are robust risk factors for adolescents' suicidal behavior (King & Merchant, 2008; Pettit et al., 2011), the present study examined social problem-solving before and after acute social stress in adolescent females and tested whether adolescents who showed greater distress-related changes (i.e., larger declines) in problem-solving self-efficacy and effectiveness were more likely to exhibit suicidal behavior over the following 9 months. Cross-sectionally, acute social stress exposure was associated with

changes in problem-solving self-efficacy, with significant declines observed among adolescents without (vs. with) past-year histories of suicidal behavior. Prospective results largely supported the primary hypothesis by showing that girls who showed greater changes (i.e., reflecting greater declines) in problem-solving effectiveness were more likely to exhibit future suicidal behavior, but only if they also experienced higher levels of real-life interpersonal stress. As expected, this effect was specific to interpersonal (vs. noninterpersonal) stress.

Adolescents showed changes in certain problem-solving domains (i.e., self-efficacy) following acute social stress, consistent with associations between acute social stressors, including social evaluation simulated using the TSST, and impairments in cognitive and behavioral domains of functioning, including problem-solving (e.g., Alexander et al., 2007). Reactivity to social stress is heightened in adolescence, particularly among females (Gunnar et al., 2009), and girls' emotional functioning and self-esteem may be more directly tied to concerns about social relationships (Rose & Rudolph, 2006). Social stressors may be particularly likely to negatively impact self-esteem-relevant domains of problem-solving, such as self-efficacy, in adolescent female samples such as this one.

When considering history of suicidal behavior, problem-solving self-efficacy was lower at baseline among adolescent girls with (vs. without) a past-year history of suicidal behavior. Problem-solving deficits in suicidal adolescents (Arie et al., 2008; Sadowski & Kelley, 1993) may be related to prior suicidal behavior through several mechanisms. Lower self-efficacy may inhibit adaptive problem-solving, perpetuating adverse effects of social stressors (e.g., feelings of defeat or entrapment) and increasing suicidal behavior risk (Panagioti et al., 2012). Engagement in suicidal behavior also may contribute to low self-efficacy, insofar as these behaviors may themselves represent unsuccessful problem-solving attempts (e.g., interrupted or aborted suicide attempts). In contrast, changes (i.e., declines) in self-efficacy following social stress were observed only among adolescents without past-year suicidal behavior, which may reflect more habituated or self-

³ Identical patterns of results were found for all prospective analyses, including interactions of social problem-solving variables with both interpersonal and noninterpersonal stress when models included a lifetime (i.e., instead of past-year) history of suicidal behavior at baseline as a covariate.

Table 2

Interpersonal Stress Moderates the Association Between Change in Problem-Solving Effectiveness Following Acute Social Stress and the Presence of Suicidal Behavior Over a 9-Month Follow-Up

Variable	χ^2	OR (95% CI)	<i>p</i>
Step 1. Covariates	13.92**		
Past-year SB history at baseline ^a		3.83 (1.22–12.00)	.02*
Baseline effectiveness		1.10 (0.63–1.95)	.72
Age		1.22 (0.81–1.84)	.35
Baseline depressive symptoms		2.59 (0.62–10.81)	.19
Step 2. Main effects	14.02*		
Δ Effectiveness		0.90 (0.48–1.71)	.75
Step 3. Moderator	18.14*		
Interpersonal stress		0.95 (0.52–1.74)	.87
Baseline Effectiveness \times Interpersonal Stress		2.19 (0.98–4.93)	.06
Step 4. Interaction	23.64**		
Δ Effectiveness \times Interpersonal Stress		0.36 (0.15–0.87)	.02*

Note. OR = odds ratio; CI = confidence interval; SB = suicidal behavior (i.e., suicide plan; interrupted or aborted suicide attempt; and/or suicide attempt).

^a Reference group: past-year SB present.

p* < .05. *p* < .01.

protective responses to social stress among those with histories of suicidal behavior (Taylor et al., 2011). Changes in self-efficacy may also have been less likely to reach statistical significance for this group due to lower self-efficacy at baseline.

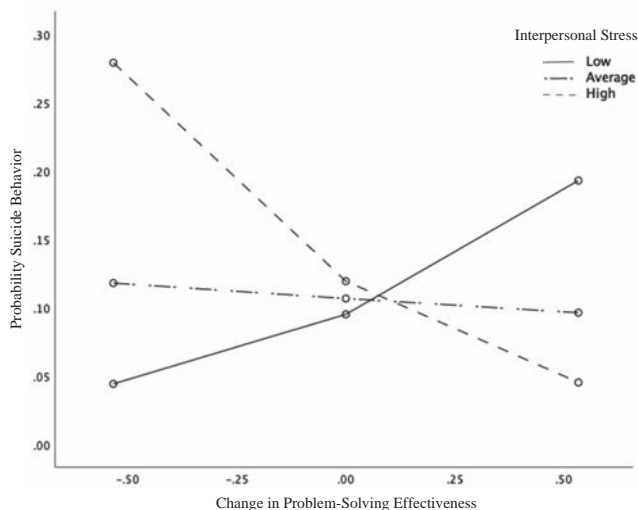
As hypothesized, and in line with cognitive and behavioral models of suicidal behavior (Pollock & Williams, 1998; Spirito et al., 2012), adolescents whose problem-solving effectiveness showed

greater change (i.e., reflecting declines) following acute social stress, and who experienced greater interpersonal stress in their real lives, were more likely to engage in suicidal behavior over the 9-month follow-up. This association was found even when statistically controlling for depressive symptoms, consistent with other work (Pollock & Williams, 2001; Williams et al., 2005). Poor problem-solving may confer risk for suicidal behavior insofar as these behaviors may be perceived as viable solutions to distress or a means of achieving relief or escape—perhaps especially when prior options have been exhausted (Baumeister, 1990; Shneidman, 1998). Thoughts of suicide are associated with subsequent reductions in negative affect (Kleiman et al., 2018), and the probability of suicidal behavior may increase when suicide is associated with desirable consequences (e.g., escape from something unpleasant; Huang et al., 2020). Motivations for suicidal behavior may be particularly salient in contexts of interpersonal stress. When presented with a hypothetical choice between virtual reality-simulated suicide and other options, participants who had undergone a social stressor task (i.e., the TSST) more frequently selected suicide over alternatives involving social stress, compared to both a control and third condition wherein suicide was not associated with avoidance of further social stress (Huang et al., 2020). These findings support the effects of both interpersonal stress and anticipated consequences of suicidal behavior (e.g., avoidance, relief from distress) on the likelihood of suicidal behavior. Greater declines in problem-solving effectiveness following social stress may increase suicidal behavior risk due in part to the anticipated potential of suicidal behaviors to provide desired outcomes, such as relief or escape.

Results specifically showed that a greater *change* in effectiveness following social stress predicted the future presence of suicidal behavior. This distinction is important given evidence that within-person change in risk factors may predict heightened risk for future psychopathology, including suicidal outcomes, above and beyond an individual's average level (Miller et al., 2017). Consistent with conceptualizations of suicide as resulting from interactions among basic, normally adaptive processes that may become maladaptive under certain conditions (Millner et al., 2020), state-dependent changes in problem-solving effectiveness following acute social

Figure 1

The Interaction Effect of Change in Problem-Solving Effectiveness and Interpersonal Stress (i.e., Over a 9-Month Follow-Up) on the Probability of Suicidal Behavior Over a 9-Month Follow-Up



Note. Simple slopes were plotted at low (-1 SD), average (*M*), and high ($+1$ SD) levels of interpersonal stress. The simple slope of change in problem-solving effectiveness on probability of suicidal behavior was significant at high levels of interpersonal stress. Regarding change in problem-solving effectiveness (*x*-axis), negative scores represent greater declines in effectiveness, whereas positive scores represent greater increases in effectiveness following acute social stress. Log odds of suicidal behavior were converted to probability (*y*-axis) to facilitate interpretability. *SD* = standard deviation.

stress may distinguish those at elevated risk for suicidal behavior. Our finding complements a cross-sectional study showing declines in problem-solving effectiveness following negative mood induction among adults with (but not without) suicidal ideation histories (Williams et al., 2005) and contributes to understanding of distress-related, cognitive-behavioral vulnerabilities that may play a role in suicidal behavior. For example, suicidal individuals have shown a bias for an active response to escape under experimentally simulated distress (Millner et al., 2019), which may reflect decision-making biases associated with suicidal outcomes, including greater sensitivity to internal emotional states (Dombrovski & Hallquist, 2017). This “active-escape bias” is consistent with clinical conceptualizations of suicidal behaviors as maladaptive coping strategies to achieve relief from aversive internal states. Similar vulnerabilities may underlie problem-solving deficits following social stress, wherein capacities to enact effective problem-solving behaviors—which may require engagement with (vs. escape from) problematic scenarios or tolerance of short-term distress to achieve better solutions—are reduced. Changes (i.e., declines) in problem-solving effectiveness may also reflect tendencies to resort to familiar, but less effective, problem-solving behavior—including suicidal behavior—when capacities to enact more situation-appropriate solutions are impacted (Dombrovski & Hallquist, 2022). Alternatively, susceptibility to distracting (e.g., distressing) social-environmental information, or poor problem conceptualization, may interfere with effective solution enactment (Szanto et al., 2015). These speculative interpretations could be explored in future work by testing other cognitive functioning domains (e.g., attention) or traits (e.g., disinhibition) as covariates or moderators.

Importantly, problem-solving deficits under distress may increase risk for future suicidal behavior only in combination with greater cumulative interpersonal stress in real life. The risk for suicidal behavior was higher among adolescents who showed greater changes (i.e., declines) in effectiveness and who experienced high levels of interpersonal stress over the 9-month follow-up, consistent with robust evidence for links between interpersonal life stress and suicidal behavior (Liu & Miller, 2014; Pettit et al., 2011). While we did not test a mediation model nor examine temporal associations among interpersonal stress and suicidal behavior across finer timescales, prior work supports bidirectional effects whereby life stress—particularly interpersonal stress—is a risk factor for suicidal behavior (i.e., stress exposure; Bagge et al., 2013), and suicidal behavior is also associated with subsequent increases in life stress (i.e., stress generation; Liu & Spirito, 2019). These temporal associations may be reciprocal and occur over finer timescales, as shown in studies of other self-injurious outcomes (e.g., suicidal ideation, nonsuicidal self-injury) using methodologies (e.g., ecological momentary assessment) well-suited to elucidate such temporal relations across shorter timescales (Glenn et al., 2022; Snir et al., 2015). Continued study of the temporal associations among social problem-solving, interpersonal stress, and suicidal behavior—including the potential impact of interpersonal stress on subsequent occurrence of suicidal behavior, or of suicidal behavior on reports of interpersonal stress,⁴ among those with poorer problem-solving—would benefit from more fine-grained assessment approaches in future work. Importantly, results from the present study help establish longitudinal support for the role of social problem-solving in the risk for future suicidal behavior.

Problem-solving was not associated with suicidal behavior in contexts of heightened noninterpersonal stress. Social problem-

solving may be less relevant to stressors not directly involving interactions or relationships with others, and thus deficits in this skillset may be less likely to influence (i.e., exacerbate) the potentially adverse effects of noninterpersonal stressors. Interpersonal stress, meanwhile, may also be particularly deleterious among adolescent females (Slavich et al., 2020), and sex differences in interpersonal stress exposure and reactivity may contribute to females’ elevated risk for certain psychopathology (Shih et al., 2006). Additional facets of gender identity may compound the deleterious effects of social stress on problem-solving in ways that increase the risk for suicidal behavior. Adolescents assigned female at birth, but who identify as sexual and/or gender minority, may be at even greater risk for experiencing interpersonal stressors and for engaging in suicidal behavior (Fox, Millner, et al., 2018; Fox, Hooley, et al., 2018), possibly due to the impact of such stressors on cognitive factors such as self-esteem (Oginni et al., 2019). Other aspects of sociodemographic diversity may also influence adolescents’ susceptibility or responses to interpersonal stressors in ways that moderate the risk for suicide-related outcomes (Xiao & Lindsey, 2021). Future studies might explore the potential interactive effects of sexual and/or gender identity and sociodemographic factors on associations between social problem-solving and suicidal behavior risk to explore the generalizability of the present findings to diverse populations.

This study demonstrated that state-dependent changes in problem-solving may temporally precede the occurrence of suicidal behavior in adolescent girls. Findings show that these changes may be risk factors in contexts of elevated, real-life interpersonal stress and highlight a potential mechanism that may underlie previously reported associations among proximal social stress reactivity, elevated interpersonal stress, and elevated suicide risk in adolescence (Miller & Prinstein, 2019). This study benefited from objective measures of key variables (i.e., problem-solving effectiveness, life stress), which were not reliant on self-report and, in the case of life stress, avoided confounding stress exposure itself with other vulnerabilities (e.g., cognitive appraisals of stress) that may contribute to suicide risk (Liu et al., 2016). While attrition and relatively low endorsement of suicidal behavior over follow-up were limitations, retention and low base rates of suicidal behavior are common limitations in research on this outcome (Borges et al., 2006; Prinstein, 2008). Finally, the lab-based design was unable to test the extent to which the TSST invoked problem-solving changes that may mirror those occurring in real life with actual peers or even during a suicidal crisis. Future work might assess problem-solving in naturalistic conditions (i.e., following real-life social stressors) and in more diverse samples to improve generalizability. Similarly, future studies might explore whether associations among social problem-solving, interpersonal stress, and suicidal behavior differ based on additional demographic factors (e.g., gender identity).

This study fills critical gaps in the literature on adolescent suicidal behavior by examining state-dependent changes in a cognitive risk factor (i.e., social problem-solving) and its interaction with social

⁴ We note the additional possibility that recent engagement in suicidal behavior impacted youths’ reports of life stress, including interpersonal stress. However, reports of life events via the YLSI were rigorously coded to yield objective consensus ratings of life stress, which may decrease the potential influence of participant reporting bias (i.e., due to recent suicidal behavior or concomitants such as negative affect), compared to self-report.

context (i.e., interpersonal stress). Interventions that focus on social problem-solving skills may reduce the risk for suicidal behavior in adolescence, and problem-solving abilities have been shown to moderate the impact of cognitive behavioral therapy-based treatments on other suicidal outcomes (i.e., suicidal ideation; Becker-Weidman et al., 2010; Salkovskis et al., 1990). Interventions that specifically target problem-solving effectiveness may be particularly promising, alongside approaches that build coping skills for interpersonal stressors.

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Received August 8, 2022

Revision received February 27, 2023

Accepted March 1, 2023 ■