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An examination of environmental and genetic contributions to the determinants of suicidal behavior among male twins

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Abstract

The purpose of the present study was to examine the relative association of genetic and environmental factors with individual differences in each of the proximal, jointly necessary, and sufficient causes for suicidal behavior, according to the Interpersonal-Psychological Theory of Suicide (IPTS; Joiner, 2005). We examined data on derived scales measuring acquired capability, belongingness, and burdensomeness (the determinants of suicidal behavior, according to theory) from 348 adolescent male twins. Univariate biometrical models were used to estimate the magnitude of additive genetic (A), non-additive genetic (D), shared environmental (C), and nonshared environmental (E) effects associated with the variance in acquired capability, belongingness, and burdensomeness. The best fitting model for the acquired capability allowed for additive genetic and environmental effects, whereas the best fitting model for burdensomeness and belongingness allowed for shared and nonshared environmental effects. The present research extends prior work by specifying the environmental and genetic contributions to the components of the IPTS, and our findings suggest that belongingness and burdensomeness may be more appropriate targets for clinical intervention than acquired capability as these factors may be more malleable or amenable to change.

Keywords

suicide; suicidal ideation; suicidal behavior; twin studies; heritability

1. Introduction

The connection between heredity and suicide has long been noted anecdotally. For instance, many are aware of the history of suicide among the Hemingways: Ernest Hemingway, his father, Clarence, his brother, Leicaster, his sister, Ursula, and his granddaughter, Margaux, all died by suicide. John Berryman, the poet, killed himself by jumping off a bridge in Minneapolis, and his father, John Smith, shot himself. Henry Fonda's first two wives,

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Margaret Sullivan and Frances Ford Seymor, died by suicide, and his son, Peter Fonda, attempted suicide. These examples are more than anecdotes, however, as they are backed by a host of genetic, familial, and twin studies, echoing the finding that suicide tends to run in families (e.g., Tsuang, 1977; Schulsinger et al., 1979; Roy and Segal, 2001; Qin et al., 2003; Runeson and Asberg, 2003).

There have been a number of studies that have examined whether genetic factors are associated with individual differences in suicide and, overwhelmingly, these studies have found a genetic component accounting for between 40-50% of the variance. Although this implicates a strong genetic influence on suicidal behavior, the remaining 50-60% of the variance is accounted for by psychological and environmental factors. Consistent with this are decades of research that have identified important psychological risk factors for suicidal behavior (e.g., depression, bipolar disorder, schizophrenia, anorexia, borderline personality disorder; Joiner et al., 2009) and environmental risk factors for suicidal behavior such as childhood abuse, unemployment, and incarceration (e.g., Beautrais, 2001; Plunkett et al., 2001; Binswanger et al., 2007; Kariminia et al., 2007; Bastia and Kar, 2009). A recent theory of suicide offers direction for the continued investigation of psychological, genetic, and environmental factors associated with suicide.

The Interpersonal-Psychological Theory of Suicide (IPTS; Joiner, 2005; Van Orden et al., 2010) is a comprehensive theory about the proximal, jointly necessary, and sufficient causes for suicidal behavior. According to the Interpersonal-Psychological Theory of Suicide, the three causal factors for suicide are perceived burdensomeness, failed belongingness, and the acquired capability for suicide (Joiner, 2005; Van Orden et al., 2010). The theory posits that in order for someone to die by suicide he or she has to both desire suicide and have the capability to enact lethal self-injury. When experienced simultaneously, failed belongingness and perceived burdensomeness are believed to cause the desire for suicide. Failed belongingness refers to feelings of loneliness and the perception that one does not have caring relationships. Perceived burdensomeness occurs when someone makes the miscalculation that his or her death is worth more to others than his or her life. Perceived burdensomeness is characterized by feelings of ineffectiveness, and can result from external factors such job loss, physical illness, and family conflict (Van Orden et al., 2010). According to the theory, lethal suicidal behavior will not occur until a third factor is present —the acquired capability for suicide. The acquired capability for suicide refers to a fearlessness about death and physical pain, which develops over time through repeated exposure to painful and/or fear-inducing experiences. Examples of these experiences include, but are not limited to, self-injury, physical or sexual abuse, combat exposure, contact sports, promiscuous sex, and physical fights. It is worth noting that one can have high levels of acquired capability, but no desire for death (e.g., veterans with strong social ties, doctors who feel very effective).

The purpose of the present study was to examine the influence of genetics and environment on the psychological factors of the three constructs in the Interpersonal-Psychological Theory of Suicide (Joiner, 2005; Van Orden et al., 2010). Twin data are appropriate for answering these types of research questions because twins either share all of their genes in the case of monozygotic (MZ) twins or approximately half of their segregating genes in the case of dizygotic (DZ) twins. Through comparisons of correlations among MZ and DZ twins on particular outcomes, researchers can determine the relative contributions of additive genetic effects, non-additive genetic effects, shared environmental effects, and nonshared environmental effects on a given outcome. Genetic effects are largely assumed to be additive, in which alleles “add up” to affect behavior. However, some genetic effects can be interactive, such that their effects differ depending on the presence of other alleles; these are non-additive genetic effects. Shared environmental factors include those occurrences and

situations experienced by both twins that act to make them more similar, such as socioeconomic status and family cohesion or conflict. Unique to individuals are nonshared environmental factors, such as physical illness, unemployment, and different friends.

We hypothesized that failed belongingness and perceived burdensomeness would exhibit substantial environmental influences, whereas the acquired capability for suicide would have strong genetic effects. We believed that perceived burdensomeness would be best explained by environmental factors because one's sense of effectiveness (an important component of perceived burdensomeness) is affected by environmental factors such as family conflict, unemployment, and physical illness (Van Orden et al., 2010). Further, these types of environmental factors are likely to be shared, as in the case of family conflict, and non-shared, as in the case of unemployment and peer conflict. Thus, we hypothesized that the best fitting model for perceived burdensomeness would be one in which both shared and non-shared environmental effects accounted for the most variance.

We expected environmental effects to account for significant variance in the failed belongingness model because one aspect of this construct is the absence of reciprocally meaningful relationships. Further, we believed the lack of reciprocally meaningful relationships would potentially be influenced by both shared and nonshared environmental factors. Van Orden et al. (2010) theorized that the absence of reciprocal care can result from situations such as family conflict (shared environmental factors), domestic violence, or loss through death and divorce (non-shared environmental factors). We allowed for the possibility of a genetic contribution to failed belongingness as research has found that loneliness (the other aspect of failed belongingness) appears to be heritable. For example, two studies (McGurie and Clifford, 2000; Boomsma et al., 2005) found heritability estimates of loneliness to be close to 50% in children and adults.

The acquired capability for suicide was expected to have strong genetic and non-shared environmental effects because this construct involves pain tolerance and fearlessness about death, which result from experiences with pain and provocation. Although experiences with pain and provocation are influenced by temperament and disposition, these types of painful experiences are likely to be unique to the individual in his or her environment, rather than shared between individuals. With respect to a potential genetic component of the acquired capability, both pain tolerance and fearlessness have been found to be heritable. In mice, heritability estimates of hot and cold pain have been found to be strong (0.41-0.50; Mogil and Adhikari, 1999). In humans, Birklein and colleagues (2008) found evidence for the heritability of both cold pain and mechanical pain. Additionally, personality traits, such as impulsivity, that increase the likelihood of engaging in painful and or provocative behavior (Bender et al., 2011) have been found to be heritable (Coccaro et al., 1993; Bevilacqua et al., 2010). Further support for a genetic contribution to the acquired capability for suicide comes from studies that have found evidence for a relationship between impulsive and aggressive personality and familial suicidal behavior. For instance, Brent and colleagues (1996) found that higher ratings of aggression were associated with higher familial loading for suicide attempts among suicide probands, as compared to demographically similar controls. Kim and colleagues (2005) found that aggressive behavior was significantly higher in the living first-degree relatives of suicide completers as compared to the relatives of comparison subjects. Additionally, several reviews have found strong support for impulsive-aggressive traits as endophenotypes for suicidal behavior (Carballo et al., 2008; Man et al., 2009).

2. Methods

2.1. Subjects

Subjects for this study were a subsample of the 578 male monozygotic (MZ) and dizygotic (DZ) twins ages 16-18 (M = 17, SD = .45) participating in the Minnesota Twin Family Study (MTFS). Due to missing data on measures of interest, the final participants in this study were 348 male MZ and DZ twins (116 MZ twin pairs and 58 DZ twin pairs). Participants included in the study did not differ from excluded participants on suicide-relevant variables, such as depression and number of previous suicide attempts. Only males were included in the study because several scales necessary for the analyses were not given to females as part of the MTFS protocol. Iacono and colleagues (1999) outline the overall sample and participant recruitment. Briefly, Minnesota state birth records from 1972-1984 were examined to ascertain twin pairs born in the state in the age range noted above. Over 90% of all twin births (i.e., 3,329 twin pairs) were located and contacted to determine study eligibility. To be included, families had to live within a day's drive of Minneapolis. Families of twins were excluded if the twins were adopted by nonrelatives, could not participate in a day-long study, or if the mother reported in the screening interview that either of the twins had an intellectual disability or disorder that would preclude participation (e.g., psychotic disorder). A total of 2,155 twin pairs were recruited and approximately 18% of recruited families refused to participate. For 82% of the non-participating families, a brief telephone interview or self-report questionnaire was obtained to investigate sampling biases. Participating families did not differ markedly from non-participating families in parental education, parental occupational status, or parental mental health. The sample is predominately Caucasian (98%) reflecting the demographics of Minnesota at the time of the twins' birth. Parents provided written informed consent and teenagers gave written assent. Participants were paid for their participation. The measures used in this study were created from items administered on various instruments administered in the MTFS (see Measures section for additional information) and this resulted in variable Ns across measures.

2.2. Measures

For the current study we did not have access to measures specifically designed to assess the Interpersonal-Psychological Theory of Suicide's constructs; thus, we used various items from the existing MTFS data to create proxy scales of acquired capability, belongingness, and burdensomeness. Although there are inherent limitations to this approach, we took special efforts to validate the constructs. First, two of the study authors (A.S. and J.R.) reviewed all of the questionnaires included in the MTFS data and independently selected items that they thought exemplified the constructs of interest. The lists were then reviewed by the authors; items that were consistent across lists were retained; discrepant items were reviewed by another author (T.J.), and decisions about whether to retain or exclude an item were reached by consensus. See Table 1 for a complete list of the items from the derived scales. To test the construct validity of these derived scales, the authors collected data from a university student sample using both the derived scales of belongingness, burdensomeness, and acquired capability and the published scales (Van Orden et al., 2008; Bender et al., 2011) designed to measure these constructs. The data were collected on 213 college students from a large southeastern university. The sample was predominantly Caucasian (85%) and the mean age was 19.25 (SD = 3.03).

The Interpersonal Needs Questionnaire (Van Orden et al., 2008) is a 15-item measure designed to assess current beliefs about the extent to which an individual feels connected to others (i.e., belongingness) and the extent to which they feel like a burden on the people in their lives (i.e., burdensomeness). Items measure both belongingness (e.g., "These days

other people care about me"), and burdensomeness (e.g., "These days I feel like a burden on the people in my life").

The Acquired Capability for Suicide Scale (Bender et al., 2011) is a 20-item measure designed to assess pain tolerance and fearlessness about lethal self-injury. Examples of items include, "The fact that I am going to die does not affect me" and "I can tolerate more pain than most people."

The correlations between the derived and published scales were significant at the $p < 0.001$ level (belongingness, $r = 0.73$, burdensomeness, $r = 0.35$, acquired capability, $r = 0.53$. Additionally, the derived scales were evaluated for construct validity in the MTFS sample by examining theoretically interesting selected correlates. The derived scale of belongingness was positively correlated with two scales derived via exploratory factor analysis from the Socialization scale of the California Psychological Inventory (Gough, 1975), optimism ($r = 0.35$, $p < 0.001$) and family ($r = 0.25$, $p < 0.001$); derived burdensomeness was negatively correlated with optimism ($r = -0.28$, $p < 0.001$) and family ($r = -0.23$, $p < 0.001$); and derived acquired capability trended towards a significant correlation with number of lifetime suicide attempts ($r = 0.11$, $p = 0.06$).

2.2.1. Acquired capability—The construct of acquired capability was assessed using 11 items (alpha = 0.32); see Table 1 for the content of the derived scale. This alpha level is low enough to suggest that alpha may be inappropriate for the assessment of scale reliability. Specifically, the types of behaviors on this scale are different enough that participants may engage in some of the behaviors, but not others; thus, alpha may not be accurately capturing reliability. Further, this scale demonstrated a correlation ($r = 0.53$) with the published measure of acquired capability and the MZ intraclass correlation ($r = 0.49$) for acquired capability was higher than the alpha of 0.32. These facts suggest that the scale is more reliable than the alpha indicates. The acquired capability items were drawn from the scales created by MTFS staff that tap leisure time interests and personality (questions ask participants to rate the extent they exhibit certain characteristics, like being adventurous, aggressive, and thrill-seeking). Higher scores indicate greater experience with painful and provocative events. Total scores were calculated for individuals who had data for at least 10 items.

2.2.2. Belongingness—The construct of belongingness was assessed using 17 items (alpha = 0.76); see Table 1. These items were taken from scales created by MTFS staff such as personality self-ratings and the Minnesota Temperament Inventory created by MTFS staff. Total scores were calculated for individuals who had data for at least 15 items.

2.2.3. Burdensomeness—The construct of burdensomeness was assessed using 8 items (alpha = 0.58); see Table 1. Although this alpha falls in the low range of acceptability, evidence for this scale's validity includes its significant ($p < 0.001$) correlation with the published scale measuring burdensomeness. These items were taken from scales such as the Multidimensional Personality Questionnaire (Tellegen, 2000), and the Inventory of Self-Ratings. Higher scores indicate greater feelings of ineffectiveness and perceived burdensomeness. Total scores were calculated for individuals who had data for at least 7 items.

3. Results

Distributions of the total scores for the acquired capability, belongingness, and burdensomeness scales were examined for normality and did not require transformations, though data for two twin pairs were removed from analyses due to outlying scores. Table 2

presents the means and standard deviations for these scales by zygosity. An independent samples t-test and Levene's Test for Equality were used to compare means and variances across zygosity. Because these tests assume independence of observations, one member from each twin pair was randomly selected for this analysis. There were no significant differences between means and variances for MZ and DZ twins for any of the scales.

Pearson correlations between the acquired capability, belongingness, and burdensomeness scales by zygosity were as follows: MZ twins, acquired capability and belongingness (r = 0.03), acquired capability and burdensomeness (r = 0.06), burdensomeness and belongingness (r = -0.44); DZ twins, acquired capability and belongingness (r = 0.06), acquired capability and burdensomeness (r = -0.03), burdensomeness and belongingness (r = − 0.58). Acquired capability and suicidal desire can and often do exist independently of one another, and as expected, in the current study, acquired capability was not significantly related to either of the other two scales. However, there was a significant negative relationship ($p < 0.01$) between belongingness and burdensomeness for both MZ and DZ twins. Given the nature of these two constructs, this relationship was expected.

As can be seen in Table 3, the correlation for acquired capability for MZ twins was higher than the correlation for DZ twins, and this difference was significant ($z = 2.38$, $p < 0.02$). The MZ correlation was more than double the magnitude of the DZ correlation, suggesting a non-additive genetic effect on Acquired Capability. The intraclass correlations did not differ significantly by zygosity for the other two scales and the similar magnitudes of the correlations across zygosity indicated shared environmental influence on each scale.

Cross-twin, cross-trait correlations are also presented in Table 3. For both MZ and DZ twins, acquired capability in one member of the twin pair was not significantly related to belongingness or burdensomeness of the co-twin. However, there was a significant cross-twin, cross-trait relationship between belongingness and burdensomeness for both MZ and DZ twins. The magnitudes of the cross-twin cross-trait correlations were similar across zygosity suggesting shared environmental influences on the covariation of these traits.

Univariate biometrical models were used to estimate the magnitude of additive genetic (A), non-additive genetic (D), shared environmental (C), and nonshared environmental (E) effects associated with the variance in acquired capability, belongingness, and burdensomeness. For each construct, the full model was fit first, followed by reduced, nested models. Overall fit for each model was assessed using the chi-square statistic, with nonsignificant values indicating adequately fitting models. Reduced models were compared to the full model using chi-square difference testing. A non-significant chi-square difference test suggests that the reduced, more parsimonious model can be chosen as the better fitting model. If more than one reduced model had a nonsignificant chi-square difference when compared to the full model, other fit indices, specifically Akaike's Information Criterion (AIC) and Root Mean Squared Error of Approximation (RMSEA), were used to determine which was the best fitting model. Lower AIC values indicate better fit and RMSEA values below .05 indicate a good fitting model.

Results of the univariate model fitting analyses are presented in Table 4 with the best fitting model depicted in bold type. For acquired capability, the ACE model had a nonsignificant chi-square value, indicating adequate fit. However, given that the intraclass correlations for acquired capability suggested a non-additive genetic effect, the ADE model was also fit and compared to the ACE model. The AIC value was lower for the ADE model, suggesting that it is a better baseline model. When the nested models were compared to the ADE model using a chi-square difference test, only the AE model had a nonsignificant chi-square difference, suggesting that it was the best fitting model. For belongingness and

burdensomeness, the ACE, AE, and CE models all had nonsignificant chi-square values, indicating adequate fit. For belongingness and burdensomeness, both the AE and CE models had a nonsignificant chi-square difference when compared to the full models. For belongingness, the CE model had a slightly lower AIC, suggesting that it was the best fitting model. For burdensomeness the differences between AIC and RMSEA values for the AE and CE models were too small to interpret. However, given that the intraclass correlations did not provide evidence for a genetic effect on burdensomeness, it was determined that the CE model was the better fitting model. To summarize, the best fitting model for the acquired capability allowed for additive genetic and environmental effects, whereas the best fitting model for burdensomeness and belongingness allowed for shared and nonshared environmental effects.

4. Discussion

When examined broadly, suicidality has been linked to both environmental and genetic etiological influences (Statham et al., 1998; Glowinski et al., 2001; Fu et al., 2002). The present research extends prior work by specifying the environmental and genetic contributions to the components of one prominent theory of suicidal behavior, the Interpersonal-Psychological Theory of Suicide (Joiner, 2005; Van Orden et al., 2010). Results were largely in line with our hypotheses.

Environmental influences appear to play an important role in the etiology of belongingness and burdensomeness, whereas analyses failed to support a significant genetic contribution on these factors. Model-fitting results were less definitive in the case of burdensomeness in that two models appeared to reasonably represent the data – one suggesting environmental influences alone and the other supporting an association with genes and environment. Given the pattern evident in the intraclass correlations, the model that included shared and non-shared environmental influences was selected as the superior model. These findings were in line with our prediction that both burdensomeness and belongingness would show strong environmental effects. The failure to find a genetic contribution to belongingness and burdensomeness may, in part, be explained by prior research indicating familial transmission of ideation (in contrast to suicidal behavior) seems to be accounted for by the familial transmission of a psychiatric disorder (Brent and Melhelm, 2008). Belongingness and burdensomeness, within the framework of the theory, represent more proximal risk factors for suicidal ideation than they do for psychiatric disorders. Further, the etiological influences on belongingness and burdensomeness appear to be related. Given that both facets of the theory are interpersonal in nature and must co-occur to produce suicidal ideation, it is not surprising that their etiology is due to environmental factors.

The etiological influences associated with acquired capability appear to be distinct from those associated with belongingness and burdensomeness. This finding is in line with our expectations given that the Interpersonal-Psychological Theory of Suicide (Joiner, 2005; Van Orden et al., 2010) does not suggest that belongingness and burdensomeness are related necessarily to the development of acquired capability. Acquired capability appears to be influenced by a combination of both genetic and non-shared environmental factors. Of note, the MZ twin intraclass correlation was greater than twice the DZ correlation, suggesting nonadditive genetic effects (e.g., genetic dominance) may play a role in the etiology of acquired capability. However, model-fitting results suggested the data were better explained by a model including only additive genetic effects and non-shared environmental influences; this latter finding is likely attributable to factors such as misadventure with peers. By extension, these results would be consistent with evidence for genetic influences on suicidal behavior and death by suicide.

Importantly, identifying whether a phenomenon is environmentally or genetically based is only a first step. A crucial next step in this area would be to identify the mechanisms that account for the environmental and genetic contributions for each component of the theory. Regarding the environment, looking to factors that foster a sense of loneliness and absence of reciprocal care would be indicated. Van Orden and colleagues (2010) highlight the role of social isolation, social withdrawal, interpersonal loss, family conflict, childhood maltreatment, and lack of social support. Perceived burdensomeness is conceptualized as the combination of being a liability to others and self-hatred. As such, environmental factors such as unemployment, physical illness, incarceration, and child abuse may be important to consider (Van Orden et al., 2010). With respect to environmental factors influencing acquired capability the theory posits that repeated exposure to painful and provocative events is key in the development of the acquired capability – experiences such as childhood maltreatment, reckless behaviors, and past suicide attempts may prove particularly salient based on past evidence (Van Orden et al., 2010).

Regarding candidate gene systems potentially associated with acquired capability, several are indicated based on prior research. To date, research on the molecular genetics of suicidal behavior has been largely focused on the serotonergic system (Mann et al., 2009) – in particular, evidence supports the role of serotonin receptors (5-HT1A, 5-HT1B, and 5-HT2A) and the serotonin transporter (SERT). In addition, monoamine oxidase-A (MAO-A) as well as genes for catechol-O-methyl transferase (COMT), tryptophan hydroxylase (TPH1 and TPH2 isoforms) and tyrosine hydrolase (TH; cf. Mann et al., 2009 and Ozalp et al., 2009 for reviews) have received empirical attention and accumulated support. Several of these genes have also, interestingly, been implicated in aggression (i.e., 5-HT1A [Zouk et al., 2007], 5HT2A [Giegling et al., 2002], MAO-A [Manuck et al., 2000], and TPH1 [Brezo et al., 2008]), pain sensitivity and tolerance (e.g., COMT [MacGregor and Reavley, 2009]), and impulsivity (i.e. 5-HT2A [Preuss et al., 2001]), which are important factors to consider in relation to acquired capability.

In addition to informing future directions for research, the present findings also serve to inform clinical work. One application, should these findings be replicated, would be to inform intervention and prevention strategies. Our findings suggest that belongingness and burdensomeness may be more appropriate targets for intervention than acquired capability – that is, these factors may be more malleable or amenable to change. Although acquired capability is a necessary component for acting on suicidal desire according to the Interpersonal-Psychological Theory of Suicide (Joiner, 2005; Van Orden et al., 2010), the clear genetic influences associated with acquired capability may make it more resistant to change. Restricting or limiting access to lethal means, however, is one clear intervention that may reduce or inhibit further strengthening of the acquired capability in suicidal individuals and potentially prevent death by suicide (Van Orden et al., 2010).

Several limitations are of note in the current study. First, our findings must be interpreted with caution, given the potential impact of several measurement issues. Specifically, using proxy scales as opposed to scales designed to directly tap our constructs of interest certainly raises concerns about construct validity. Preliminary analyses did support moderate-to-strong correlations between the proxy and existing measures of the constructs, providing some evidence that the proxy measures are appropriate indicators of the constructs of interest. Concern regarding the reliability of the proxy scales may also be warranted, given the findings of the reliability analyses. However, other evidence – in particular, the strong correlations with the published scale measuring the same constructs – suggests that the scales are likely more reliable than suggested by the coefficient alpha results. Thus, although providing an internal consistency index reflecting item homogeneity, coefficient alpha may not provide the best index of how well the scales measure what may be heterogeneous

constructs, particularly in the case of acquired capability, which is comprised of both experience with pain and fearlessness (Cortina, 1993; Schmitt, 1996). Second, the MTFS study participants were adolescents between the ages of 16 and 18; however, we validated the proxy measures of the IPTS in a college student sample. Third, in addition to measurement limitations, there were constraints on statistical power for the biometric models given the low sample size. Fourth, only male twin pairs were used in our analyses since some measures from which items were taken to create the theory construct scales were not administered to females on the MTFS. As such, this limits the generalizability of our results to females. As there is some literature that suggests MZ female twins have higher concordance rates for suicide than male MZ twins (Kringlen, 1986), it is possible that there is a stronger genetic contribution to certain components of the theory for females than in males.

The study of etiological influences on suicide is critical to making inroads to prevention. As noted above, to our knowledge, this is the first study that has examined the components of the Interpersonal-Psychological Theory of Suicide using twin data, setting the stage for further investigations with genetically informed samples. It will be important to try to replicate these findings in other samples (e.g., adults, females) using scales designed to measure the theory constructs (i.e., Interpersonal Needs Questionnaire, Acquired Capability for Suicide Scale). Moving forward, future research is necessary for identifying particular environmental and genetic factors as well as possible gene-environment interactions that confer risk. Understanding these etiological influences will undoubtedly provide valuable insight and guidance for future treatment and prevention efforts.

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Table 1

Items from the derived scales of the IPTS theory constructs

Scale	Item Content
Acquired Capability for Suicide	
MPQ	Easily startled (R)
LTI	[I enjoy] Doing something exciting, even slightly dangerous
LTI	[I enjoy] Risky pastimes: hang gliding, mountain climbing, surfing, etc.
PSR	Adventurous: A high scorer likes exciting and risky adventures and hobbies (such as skydiving) and will attempt risk things that an average person might be afraid to try. A low scorer avoids risky activities.
PSR	Aggressive: A high score means that you enjoy watching a good brawl, that you sometimes like to get into fights and are ready to hit people when you're angry. A low score means you do not react this way.
PSR	Thrill-seeking: High scorers would not mind and might even enjoy being in the middle of an emergency or disaster (such as a bank hold-up, a fire, an earthquake or tornado). A low scorer if possible will make it a point to stay away from such situations.
MAB	Riding a bicycle recklessly (for example, not stopping for stop signs, riding fast on sidewalks)
MAB	Carrying some kind of weapon (for example a knife or gun) in case it is needed in a fight.
MAB	Using any kind of weapon (for example, a knife, gun, razor, or broken bottle) in a fight.
TI	I have or might threaten to harm myself in order to get my way.
TI	I am an anxious, nervous, and fearful person; tend to worry. (R)
Burdensomeness	
ISR	Dangerous: High scorers cause danger or trouble for others, people worry when they are around; low scorers do not create these problems.
ISR	Common sense: High-scorers have a solid secure confidence that they are valuable people worthy of respect. Low-scorers lack self-confidence and others get the feeling that they aren't worth very much. (R)
ISR	Contributor: Give yourself a high score if you feel that you give a lot more than you take from society. A low score means that you take more than you give. (R)
ISR	Evil: A high score means you can be really bad, an evil person; a low score means that you are never genuinely bad or evil.
ISR	Abstract intelligence: The ability to solve intellectual problems, to understand complicated issues, to figure things out; "school intelligence." (R)
ISR	Wicked: Suppose someone who knew all your secrets were to rate you for "wickedness"; if they would say you were among the least wicked 5%, give yourself a score of 1. If they would rate you in the top third, rate yourself a 4. And so on.
MPQ	Others would like to see me get hurt.
MPQ	Others are against me for no reason.
Belongingness	
PSR	Gregarious: A high scorer likes to be with people, likes to work or play with others. Give yourself a low score if you are usually happier when alone and if you prefer to work alone or with things rather than with people.
PSR	People-oriented: High scorers seek out a friend or loved one when they are unhappy or have a problem. Low scorers prefer to work out their problems alone, generally tend to keep their feelings and thoughts to themselves.
PSR	Affectionate: A high score means you are a warm, out-going person who easily expresses affection and values close personal relationships. A low score means that you are rather cool and detached and would find it relatively easy to move away from family or friends.
So	Easily let go of friends. (R)
So	Others talk about me. (R)
So	Family is close.

Acquired Capability for Suicide	
Scale	**Item Content**
So	Misunderstood by parents. (R)
So	Don't trust anyone. (R)
LTI	[I enjoy] Getting together with a lively group of friends and acquaintances.
LTI	[I enjoy] Getting together with friends, partying, etc.
ISR	[I enjoy] Participating in social organizations, groups, clubs, lodges, etc.
ISR	Affability: High-scorers tend to like most other people and get along with them. Low-scorers find it hard to stay on good terms with many of the people why have to deal with.
ISR	Liked: High-scorers have many friends people take to them, like them. Low scorers may or may not have enemies but they are not widely or well-liked.
ISR	Needed: High-scorers know that they are really needed by one or more other people; low-scorers feel that they could disappear without much effect on any other person's life.
ISR	High scorers are warm and friendly, easy to know, easy to get along with. Low scorers are likely to be cool and distant.
ISR	Disliked: High scorers tend to make people dislike and disapprove of them. Low scorers do not behave this way.
TI	I do not form close relationships with or loyalties to other people. (R)
PSR	Gregarious: A high scorer likes to be with people, likes to work or play with others. Give yourself a low score if you are usually happier when alone and if you prefer to work alone or with things rather than with people.
PSR	People-oriented: High scorers seek out a friend or loved one when they are unhappy or have a problem. Low scorers prefer to work out their problems alone, generally tend to keep their feelings and thoughts to themselves.

Note: MPQ = Multidimensional Personality Questionnaire, LTI = Leisure Time Interests, , PSR = Personality Self-Ratings , MAB = Minor Adolescent Behavior Problems, TI = Temperament Inventory , ISR = Inventory of Self-Ratings, So = Socialization scale , (R) = item was reverse scored. MPQ and So items are paraphrased due to copyright.

Table 2

Means and Standard Deviations for Acquired Capability, Belongingness, and Burdensomeness Scales for MZ and DZ Twins.

	MZ		DZ		Range	
Scale	**M**	**SD**	**M**	**SD**	**Minimum**	**Maximum**
Acquired Capability	26.74	3.63	26.54	3.58	16.00	37.00
Belongingness	47.91	6.34	49.61	6.03	26.00	61.00
Burdensomeness	18.25	3.36	18.23	4.08	9.00	29.00

Table 3

Intraclass and Cross-Twin Cross-Trait correlations for Acquired Capability, Belongingness, and Burdensomeness Scales by Zygosity.

	MZ			DZ		
Scale	**Acq. Cap.**	**Belong.**	**Burden.**	**Acq. Cap.**	**Belong.**	**Burden.**
Acq. Cap.	.485**			.101		
N	97			47		
Belong.	.113	.403**		−.184	.331*	
N	94	94		48	48	
Burden.	−.063	−.242*	.401**	.020	−.283*	.378**
N	96	96	112	52	52	58

Note. Intraclass correlations for MZ and DZ twins are presented on the diagonals. Cross-twin cross-trait correlations are presented below the diagonals. N = number of twin pairs

* = p < .05

** = p < .01

Table 4

Univariate Model-Fitting Analysis for Acquired Capability, Belongingness, and Burdensomeness.

Model	**A**	**D**	**C**	**E**	**x^2 (*df*)**	**p**	**AIC**
Acq. Cap.							
ACE	.47	---	.00	.53	1.17 (3)	.760	−4.83
ADE	.00	.48	---	.52	0.39 (3)	0.941	−5.61
AE	**.47 [.30-.60]**	---	---	**.53 [.40-.70]**	**1.17 (4)**	**.883**	**−6.83**
E	---	---	---	1.0	26.76 (5)	.000	16.76
Model	A	D	C	E	x^2 (*df*)	*p*	AIC
Belong.							
ACE	.11	---	.29	.60	1.44 (3)	.696	−4.56
AE	.42	---	---	.58	2.47 (4)	.650	−5.53
CE	---	---	**.39 [.24-.52]**	**.61 [.48-.76]**	**1.60 (4)**	**.810**	**−6.40**
E	---	---	---	1.0	24.16 (5)	.000	14.16
Model	A	D	C	E	x^2 (*df*)	*p*	AIC
Burden.							
ACE	.26	---	.19	.55	7.76 (3)	.051	1.76
AE	.48	---	---	.52	8.59 (4)	.072	0.59
CE	---	---	**.39 [.26-.51]**	**.61 [.49-.74]**	**8.92 (4)**	**.063**	**0.92**
E	---	---	---	1.0	37.15 (5)	.00	27.15

Note. The standardized proportion of variance for each parameter [and its 95% confidence interval] is provided for each model. A = additive genetic effects; D = non-additive genetic effects; C = shared environmental effects; E = nonshared environmental effects; AIC = Akaike's Information Criterion; RMSEA = Root Mean Squared Error Approximation. x^2 Δ refers to the difference in chi-square values between the full model and a reduced model. Only reduced models that had a nonsignificant chi-square were tested against the full model. The best fitting model is depicted in **bold** type.

* = p < .05.