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Inflexible Interpretations of Ambiguous Social Situations: A Novel Predictor of Suicidal Ideation and the Beliefs that Inspire It

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Abstract

Suicidal ideation has been linked to a bias toward interpreting ambiguous information in consistently less positive/more negative manners ("positive/negative interpretation bias"), implying that information processing biases might distort beliefs thought to inspire suicidal ideation (e.g., those regarding burdensomeness). The present study therefore examined whether suicidal ideation and beliefs highlighted in theories of suicide are related to positive/negative interpretation bias and/or a bias against revising negative interpretations in response to evidence against them ("negative interpretation inflexibility"). Data were collected in three waves, each one week apart. Network analyses and structural equation models provided evidence that negative interpretation bias (cross-sectionally) and negative interpretation inflexibility (cross-sectionally and over time) were related to suicidal ideation, and that the latter relationship was mediated by perceived burdensomeness. By identifying this mediation pathway, the present study provides a potential mechanism by which perceptions of burdensomeness, a key risk factor for suicidality, might arise and/or persist.

Keywords: Suicidal Ideation, Interpretation Bias, Interpretation Inflexibility, Perceived Burdensomeness

Inflexible Interpretations: A Novel Predictor of Suicidal Ideation and the Beliefs that

Inspire It

Suicide causes approximately 800,000 deaths annually (Kestel and Van Ommeren, 2019), and predicting who will attempt or die by suicide has proven challenging (Franklin et al., 2017). These facts imply that our current understanding of suicidality is inadequate for the development of sufficiently effective suicide-prevention strategies. Although most studies meant to help remedy this situation have investigated suicide-related behaviors (e.g., suicide attempts), a growing number have examined suicidal ideation (as called for by suicide researchers, see: Jobes and Joiner, 2019), which involves plans or wishes to commit suicide without overt action (Beck, Kovacs, and Weissman, 1979) and is an important step along pathways leading to suicide (Jobes and Joiner, 2019). These studies demonstrate that suicidal ideation is strikingly common (Jobes & Joiner, 2019), can cause psychological distress, and sometimes interferes with daily life (Van Spijker et al., 2014).

These studies also establish an association between suicidal ideation and cognitive inflexibility, the failure to adequately adjust decision-making behavior in response to external feedback and evolving environments (Miranda, Gallagher, Bauchner, Vaysman, & Marroquín, 2012). This association holds for multiple aspects of cognitive inflexibility (e.g., coping flexibility: Heffer & Willoughby, 2017; difficulties with set-shifting: Jyunn Lai et al., 2018), and may be causal in nature: inflexibility prospectively predicts ideation through a plausible mediating mechanism (increasing brooding and, in turn, hopelessness; Miranda et al., 2012; Miranda, Valderrama, Tsypes, Gadol, & Gallagher, 2013), and exhibits a dose-response relation with ideation (Jyunn Lai et al., 2018). These findings merit further investigation into whether additional facets of cognitive flexibility are linked to suicidal ideation and, if so, by what

potential mechanism(s). The present study focuses on one such facet — interpretation inflexibility (failure to adequately update interpretations in response to changing situational demands), a specific form of belief inflexibility (the metacognitive ability to reflect on one's beliefs and consider alternatives in light of the possibility they may be mistaken; Ward, Peters, Jackson, Day, & Garety, 2018).

While belief inflexibility has been underexamined in studies of suicidal thoughts (and behaviors), the potential relevance of belief inflexibility to suicidal ideation is evident when considering that theories of suicidality have consistently hypothesized that suicidal ideation is influenced by individuals' beliefs about their present and future circumstances. The Interpersonal Theory of Suicide (Joiner, 2005), for instance, asserts that beliefs regarding thwarted belongingness (a mental state resulting from unmet needs for connectedness) or perceived burdensomeness (a mental state characterized by [mistaken] beliefs that "others would be better off if I were gone") result in passive suicidal ideation (e.g., "I wish I were dead"), which escalates to active suicidal desire (e.g., "I would kill myself if I had the chance") if both types of beliefs are present and the interpersonal situation that begot these beliefs is deemed intractable (Chu et al., 2017). Moreover, the Three-Step Theory of Suicide (Klonsky and May, 2015) posits that suicidal ideation results when individuals experience pain (most often, psychological or emotional pain, which is referred to as psychache) and endorse beliefs about their future characterized by hopelessness (expecting negative future events one is helpless to influence; Abramson, Metalsky, and Alloy, 1989). Finally, the Integrated Motivational-Volitional Model of Suicidal Behavior (O'Connor, 2011) attributes a critical role to perceptions of defeat (failed social struggle) and entrapment (perceived inability to escape aversive situations) in the

development of suicidal ideation. Specifically, the model predicts that suicidal ideation is caused by defeating or humiliating experiences from which one believes there is no escape.

The central role beliefs play in these prominent accounts of suicidal ideation is notable because beliefs often systematically deviate from reality due to biases in information processing (e.g., confirmation bias; Nickerson, 1998). This is particularly true in the context of psychopathologies (e.g., depression; see: Everaert, Bernstein, Joormann, and Koster, 2020; Everaert, Podina, and Koster, 2017) that frequently feature suicidal ideation (Vuorilehto et al., 2014). Unsurprisingly then, research indicates that beliefs which might inspire suicidal ideation are not always congruent with reality. For example, in the context of suicidal thoughts and behaviors, perceptions of burdensomeness are most often thought to be inaccurate (Hames, Hagan, and Joiner, 2013), a position consistent with interview-based studies indicating that these perceptions are often fueled by normative experiences (e.g., in the case of adolescents: needing transportation by close others; Buitron et al., 2016).

Beliefs regarding burdensomeness (along with other beliefs that putatively inspire suicidal ideation) may become incongruent with reality due to biased interpretation (the semantic process of integrating aspects of a situation to resolve ambiguity; Blanchette and Richards, 2010). Consistent with this possibility, preliminary evidence suggests that cognitive bias modification programs designed to ameliorate interpretation bias can reduce perceived burdensomeness and suicidal ideation (Allan, Boffa, Raines, and Schmidt, 2018). As noted by Beard, Rifkin, and Björgvinsson (2017), interpretation bias may also influence beliefs about individuals' futures in a manner that promotes hopelessness and suicidal ideation. This possibility is strongly consistent with the fact that negative interpretation bias prospectively predicts hopelessness and suicidal ideation (Beevers and Miller, 2004). Interpretation bias may

distort these beliefs by interfering with the ability to accurately decipher social environments, which often feature ambiguous situations requiring interpretation (Everaert, Bronstein, Cannon, and Joormann, 2018).

Above and beyond any effect(s) of interpretation bias, interpretation inflexibility might promote additional discrepancies between reality and beliefs that inspire suicidal ideation. Consistent with this notion, inflexible negative interpretations may result in maladaptive beliefs about positive emotions (e.g., "good things won't last"), leaving individuals vulnerable to experiencing depressive symptoms (Everaert, Bronstein, Castro, Cannon, and Joormann, 2020), which often include suicidal ideation (Vuorilehto et al., 2014). Inflexible negative interpretations may also maintain overly negative appraisals of ambiguous interactions with others (potentially increasing perceived burdensomeness and thwarted belongingness) and cause individuals to discount evidence that their problems have improved (increasing hopelessness), although these possible effects of inflexible interpretations have not been evaluated in extant literature.

The Present Study

The literature reviewed above suggests that inflexible/biased interpretations may cause beliefs to deviate from reality in a manner that prompts suicidal ideation. The present study therefore examined whether inflexible and biased interpretations are related to suicidal ideation via their impact on beliefs about individuals' current and future circumstances, such as those related to perceived burdensomeness and hopelessness. This examination was conducted in two stages. First, in the tradition of several previous studies of suicidal thoughts and behaviors (Bloch-Elkouby et al., 2020; De Beurs et al., 2019), cross-sectional network analyses were employed with the goal of uncovering potential pathways by which inflexible and biased interpretations may be related to suicidal ideation and the beliefs that putatively inspire it.

Second, structural equation models were used to examine whether potential mediation pathways identified in this analysis held in a longitudinal dataset. Modeling longitudinal data was necessary to establish whether inflexible interpretations are a risk factor for suicidal ideation; risk factors by definition must precede and predict their associated outcomes. The test of mediation within these models was included to facilitate identification of plausible mechanisms temporally linking inflexible interpretations and suicidal ideation. Identifying these mechanisms is an important step toward determining whether inflexible interpretations may be a manipulative cause of suicidal ideation (see: Cox, 2018; Lervåg, 2019).

Two hypotheses were tested via these analyses. The first of these hypotheses ("*Hypothesis 1*") was that negative interpretation inflexibility and interpretation bias would be independently associated with suicidal ideation and with beliefs highlighted in major theories of suicide (e.g., the belief that one is a burden to others), and that these beliefs would mediate any relation between suicidal ideation and interpretation inflexibility or bias. The second of these hypotheses ("*Hypothesis 2*") was that negative interpretation inflexibility and interpretation bias would independently predict longitudinal increases in suicidal ideation and the endorsement of beliefs related to suicide (e.g., hopelessness).

Notably, these hypotheses were investigated using the emotional bias against disconfirmatory evidence (BADE) task (Everaert et al., 2018). This task's key strength, the ability to disentangle the effects of interpretation bias and inflexibility, allowed the present study to examine the unique relations between inflexible and/or biased interpretations and suicidal ideation. This capability is beneficial because people are generally more reluctant to revise beliefs and interpretations in which they are more confident (Kaliuzhna, Chambon, Franck, Testud, and van der Henst, 2012; Woodward, Moritz, Menon, and Klinge, 2008). This tendency

implies that failure to account for interpretation bias, which might inspire greater confidence in interpretations, could potentially confound any test of the relation between interpretation inflexibility and suicidal ideation. Accordingly, the emotional BADE task's ability to separate interpretation bias and inflexibility allows this study to rigorously test the foregoing hypotheses.

Method

Participants and recruitment

Participants ($n_{Phase\ 1}$=853, $n_{Completed\ Phase\ 2}$=207; demographics: SI Section S2) were recruited in two phases using a stratified random sampling approach to ensure adequate variability in suicidal ideation across individuals. Phase 1 served as a pre-screening. Phase 2 was the main study (attrition data: SI Section S4). Participants were Mechanical Turk (MTurk) workers. MTurk provides an online crowdsourcing platform with access to large and diverse samples suitable for clinical research collecting mental health data (Chandler and Shapiro, 2016), including studies investigating individual differences in suicidal ideation (Shahnaz, Saffer, and Klonsky, 2018). Participation was limited to MTurk workers age 18+ living in the United States. Participants received $9 (USD) remuneration.

Data quality measures

Following recommendations for research using crowdsourced samples (Chandler and Shapiro, 2016), several steps were taken to ensure high data quality. Workers were required to have a history of providing good-quality responses (i.e., an acceptance ratio of ≥ 96% in a minimum of 100 human intelligence tasks [HITs]), complete a "captcha" (to deter "participation" by computer programs), pass 5/6ths of included attention check questions (placed at irregular intervals to identify inattention), and have an IP address and MTurk ID that were not associated with low-quality data or a non-US location (Ophir, Sisso, Asterhan, Tikochinski, and

Reichart, 2018; Prims, Sisso, and Bai, 2018). Participants self-reporting that they answered Phase 1 survey questions randomly or did not follow survey instructions were not invited to participate in Phase 2. Survey measures were checked for adequate internal consistency using McDonald's Omega total (McDonald, 1999); all measures had good or excellent internal consistency across all data collection waves (see: SI Section S4). These data quality measures adhere to current standards and are strongly based on those that have yielded highly replicable results in past research (e.g., Bronstein, Pennycook, Bear, Rand, & Cannon, 2019; Everaert et al., 2018; Everaert, Bronstein, et al., 2020). Nevertheless, replication of the present study is encouraged because this is the best way to ensure the reliability of its conclusions.

Protocol

The Yale Institutional Review Board approved the study. In Phase 1, 853 MTurk workers completed the 5-item Scale for Suicide Ideation (SSI-5; the first five items of the Beck Scale for Suicide Ideaton: Beck and Steer, 1991), which determined invitations to Phase 2. As the first step in the invitation process, SSI-5 scores were recoded into three groups. Group 1 reported no suicidal ideation (SSI-5=0). The remaining groups were divided via a median split of all SSI-5 scores exceeding zero (Group 2: M=1.52, SD=0.50; Group 3: M=4.61, SD=1.77). From each group, 125 randomly-selected individuals received invitations for Phase 2 (this choice was informed by a power analysis suggesting that 375 participants would be sufficient to detect even a small effect of interpretation inflexibility on suicidal ideation: see https://osf.io/hf4e8).

Phase 2 included a baseline assessment plus two follow-up assessments (after one and two weeks, respectively). At baseline only, participants completed the emotional BADE task (Everaert et al., 2018). During all three sessions, participants completed the Beck Depression Inventory–II (Beck, Steer, and Brown, 1996), SSI-5 (Beck et al., 1979), Beck Hopelessness

Scale (Beck, Weissman, Lester, and Trexler, 1974), Interpersonal Needs Questionnaire (Van Orden, Cukrowicz, Witte, and Joiner, 2012), Scale of Psychache (Holden, Mehta, Cunningham, and McLeod, 2001), Perceived Stress Scale (Sheldon Cohen, 1994), Short Defeat and Entrapment Scale (SDES; Griffiths et al., 2015), Future Events Questionnaire (FEQ; Miranda and Mennin, 2007), and the Future-oriented Repetitive Thought - Pessimistic Repetitive Future Thinking scale (Miranda, Wheeler, Polanco-Roman, and Marroquín, 2017). Within each session, measures were presented in randomized order. Participants completed questionnaires in reference to the past week to standardize temporal orientation across questionnaires and data collection waves.

Measures: Suicidal Desire and Psychiatric History

Current Suicidal Desire

Suicidal desire was measured using the Scale for Suicide Ideation-5 (SSI-5). The SSI-5 has five items (measuring wish to live, wish to die, reasons for living/dying, desire to make an active suicide attempt, and passive suicidal desire) that capture the construct of 'suicidal desire.' For each item, participants reported which of three potential responses, organized by increasing severity, was most applicable to them. The SSI-5 was derived from the Scale for Suicide Ideation (Beck et al., 1979), a 19-item instrument evaluating the presence and intensity of suicidal thoughts over the past week. Previous research supports the 5-item version of the questionnaire (de Beurs, Fokkema, de Groot, de Keijser, and Kerkhof, 2015). The SSI-5 had good-to-excellent internal consistency in the present study (minimum: ω_{total}=.86).

Psychiatric History

Lifetime history of psychiatric diagnosis, past and current help-seeking behavior, lifetime history of suicide attempt, and the lethality of most severe suicide attempt (if any), were queried (SI Section S3).

Measures: Established Risk factors for Suicidal Ideation

Depression Symptoms

The *Beck Depression Inventory II* (BDI-II; Beck et al., 1996; present study: minimum $\omega_{total=}.96$) includes 21 items measuring depressive symptom severity. Each item queries the degree to which individuals have experienced a certain symptom on a four-point scale (range: 0-3). Total scores are calculated as the sum of these ratings. However, item 9 (which examines suicidal desire) was excluded except when reporting descriptive statistics and zero-order correlations (to avoid redundancy with the SSI-5; analyses used here-in assume lack of redundancy, see: Meier et al., 2019). The BDI-II has good reliability and validity (Dozois, Dobson, and Ahnberg, 1998). Depression is a risk factor for suicidal ideation and behavior (Henriksson et al., 1993; Isometsä, 2014), and may mediate the relation between other risk factors and suicidal ideation (Wang, Jiang, Cheung, Sun, and Chan, 2015).

Hopelessness

The Beck Hopelessness Scale (Beck et al., 1974; present study: minimum $\omega_{total=}.93$) contains 20 items measuring individuals' negative attitudes and expectations about the future, and amotivation. Individuals indicate whether self-report items are true or false for them. This measure has good internal consistency and validity (Kocalevent et al., 2017). Hopelessness is central to important theories of suicide (e.g., Abramson et al., 2006), and has been repeatedly related to suicidal ideation (e.g., Dhingra, Klonsky, and Tapola, 2019; Klonsky and May, 2015).

Burdensomeness and belongingness

The Interpersonal Needs Questionnaire (Van Orden et al., 2012; present study: minimum $\omega_{total=}$.96) has subscales assessing thwarted belongingness (i.e., beliefs about the extent to which individuals feel connected to others) and perceived burdensomeness (i.e., degree to which individuals feel they are a burden to others). Respondents rate the INQ's 15 items using a seven-point scale. The questionnaire has strong psychometric properties (Van Orden et al., 2012). Perceived burdensomeness and thwarted belongingness are the central constructs in the Interpersonal Theory of Suicide (Joiner, 2005); extensive evidence links them to suicidal ideation (Chu et al., 2017).

Psychological pain

The 13-item Scale of Psychache (Holden et al., 2001; present study: minimum $\omega_{total=}$.97) measures current emotional or mental pain. Respondents rate whether they experience various aspects of psychache on a 5-point Likert scale (1='never', 5='always'). This scale has favorable psychometric properties (Holden et al., 2001). Psychache features prominently in several theories of suicide (Klonsky and May, 2015; Shneidman, 1993), and has been consistently related to suicidal ideation (Verrocchio et al., 2016).

Perceived Stress

The Perceived Stress Scale (Cohen, Kamarck, and Mermelstein, 1983; present study: minimum $\omega_{total=}$.92) includes 10 items measuring whether situations are appraised as stressful (i.e., unpredictable, uncontrollable, and overwhelming). Items are rated on a five-point scale (range: 0='never', 4='very often'). The questionnaire has adequate internal consistency (Roberti, Harrington, and Storch, 2006). In the Integrated Motivational-Volitional Model of Suicidal Behavior, stress is thought to combine with pre-existing vulnerabilities (e.g., in biological stress-

response systems, see: Miller and Prinstein, 2019) to increase the likelihood that individuals will consider suicide (O'Connor and Kirtley, 2018). Consistent with this notion, multiple studies have observed associations between suicidal ideation and acute stress (e.g., Cole et al., 2015; O'Connor, Green, Ferguson, O'Carroll, and O'Connor, 2017).

Defeat and Entrapment

The Short Defeat and Entrapment Scale (SDES; Griffiths et al., 2015; present study: minimum $\omega_{total=}.94$) is an eight-item measure of defeat and entrapment. Each item is rated on a 0 ('Not at All Like Me') to 4 ('Extremely like me') scale. Defeat and entrapment were treated as one construct given previous research suggesting that they load onto one factor (Sturman, 2011; Taylor, Wood, Gooding, Johnson, and Tarrier, 2009; but, see: Forkmann, Teismann, Stenzel, Glaesmer, and De Beurs, 2018). Defeat and entrapment are central to the Integrated Motivational and Volitional Model of Suicidal Behavior (O'Connor, Cleare, Eschle, Wetherall, and Kirtley, 2016; O'Connor and Kirtley, 2018); extant literature strongly links these constructs to suicidal ideation (O'Connor and Portzky, 2018).

Confident Anticipation of Negative and (Few) Positive Future Events

The Future Expectancies Questionnaire (Miranda and Mennin, 2007; present study: minimum $\omega_{total=}.90$) was used to measure confidence in expectations regarding future negative and positive events. Items ask whether 34 future events (half positive/negative) will happen (yes/no), along with confidence in that prediction (on a 5 point scale; 1="Not at all certain", 5="As certain as one can be"). This questionnaire has adequate internal consistency (Krajniak, Miranda, and Wheeler, 2013; Miranda and Mennin, 2007). As measured by this questionnaire, the confident lack of positive future expectancies is associated with suicidal ideation, even when controlling for hopelessness and depression (Sargalska, Miranda, and Marroquín, 2011). This

questionnaire was included because the Integrated Motivational-Volitional Model of Suicidal

Behavior posits that beliefs about the future may influence the relation between entrapment and

suicidal ideation (O'Connor and Kirtley, 2018).

Pessimistic Repetitive Future Thinking

The Pessimistic Repetitive Future Thinking subscale of the Future-oriented Repetitive

Thought Scale (Miranda et al., 2017; present study: minimum $\omega_{total=}$.94) measures repeated

thought about whether negative (positive) future outcomes will (will not) occur. Respondents

rate eight items (from 0='never' to 4='almost always'). This subscale has proven reliable in

several studies (Miranda et al., 2017). Pessimistic repetitive future thinking has been associated

with suicidal ideation, and is elevated in individuals with a history of suicide attempts (Kirtley,

Melson, and O'Connor, 2018). This construct lies at the intersection of rumination (which the

Integrated Motivational-Volitional Model posits influences the relation between defeat and

entrapment) and future thinking (which this model posits modulates the relation between

entrapment and suicidal ideation). Pessimistic repetitive future thinking was measured because it

may alter the character of individuals' beliefs about their futures (e.g., by increasing their

certainty about predicted negative events via rehearsal), thereby encouraging suicidal ideation

(Krajniak et al., 2013).

Measures: Interpretation Bias and Inflexibility

Emotional Bias Against Disconfirmatory Evidence (BADE) task

Interpretation bias and inflexibility were examined using the Emotional Bias Against

Disconfirmatory Evidence (BADE) task (Everaert et al., 2018). During the emotional BADE

task, self-referential scenarios containing three statements were presented to participants

(example: SI Section S9). Each statement provided additional information about an unfolding

ambiguous interpersonal situation containing themes of social failure and rejection. After viewing each statement, participants rated the plausibility of four different interpretations of the information acquired thus far in that scenario using a 21-point rating scale ranging from 'poor' (a score of 1) to 'excellent' (a score of 21). Interpretations were presented in randomized order after each statement.

Across scenarios, interpretations were grouped into three categories: Absurd (e.g., "You and your old friends suddenly fall asleep"), Lure (e.g., "Your old friends decide to leave and do something else"), and True (e.g., "Your old friends think you are a fun person to spend time with") interpretations (in accordance with Everaert et al., 2018). Absurd interpretations were consistently implausible throughout each scenario. Lure interpretations (Lure-A and Lure-B; Lure interpretations are arbitrarily sorted into these categories) in each scenario were initially the most plausible, but became less so as the scenario continued. True interpretations were initially only moderately plausible, but became the most plausible interpretation by the end of the scenario. Given this structure, optimal performance on the emotional BADE task requires participants to revise beliefs about the most plausible interpretation for a given scenario by integrating the disconfirmatory information provided by each of the latter two statements.

The emotional BADE task includes two types of scenarios. *Disconfirming-the-negative* scenarios (which contain negative Lures and a positive True interpretation, inviting revision of negative interpretations in response to disconfirmatory positive information) and *disconfirming-the-positive* scenarios (which contain positive Lures and a negative True interpretation, inviting revision of positive interpretations in response to disconfirmatory negative information). Given previous research (e.g., Everaert et al., 2018) suggesting that metrics of interpretation inflexibility derived from *disconfirming-the-negative* scenarios may be more strongly related to

depressive symptoms, potentially including suicidal ideation, results regarding data from these scenarios were of central interest here-in (results from *disconfirming-the-positive* scenarios: SI Section S8).

Three metrics were derived from *disconfirming-the-negative* scenarios: negative interpretation inflexibility, negative interpretation bias, and positive interpretation bias. In previous studies (Everaert et al., 2018; Everaert, Bronstein, et al., 2020), these metrics were calculated using principal component analysis (PCA). Using PCA to score the emotional BADE task was advantageous in revealing important directions of variance in task performance. However, this method has noteworthy disadvantages (for a review, see: Bronstein and Cannon, 2018). Researchers have therefore recommended that the original BADE task (upon which the emotional BADE task was based) be scored using alternative methods (Bronstein and Cannon, 2018; Sanford, Veckenstedt, Moritz, Balzan, and Woodward, 2014). One recommended strategy is to calculate BADE task metrics as unweighted sums of the average explanation ratings loading most strongly onto each PCA-derived BADE component (Sanford et al., 2014). The present study applies this strategy to the emotional BADE task for the first time. As noted in the pre-registration for the present study, each metric was scored as follows: negative interpretation inflexibility (Absurd1+Absurd2+Absurd3+LureA3+LureB3-True3), positive interpretation bias (True1+True2+True3), and negative interpretation bias (LureA1+LureB1+LureA2+LureB2). In these formulas, numbers in variable names represent the statement after the rating was made, while the remainder of the name denotes the category of explanation being rated.

Analyses

The primary analyses in the present study (those involving network analysis and longitudinal structural equation modeling) were pre-registered (https://osf.io/8hnfc/?view_only=17932853a4a3486585d78e1f86bb9554; https://osf.io/hf4e8).

Outliers and Missing Data

Outliers were detected using the method of Hubert and Van Der Veeken (2008), as pre-registered, because this method was designed for detecting outliers in skewed data; several variables in the present study (interpretation inflexibility, suicidal ideation) were right skewed. Detected outliers were winsorized (Fuller, 1991). Analyses of cross-sectional data were conducted after removing participants with missing data list-wise. Analyses of longitudinal data were conducted with these participants included, using proper missing data handling techniques (see below).

Hypothesis 1: Cross-sectional associations between suicidal ideation, suicide-related beliefs, and interpretation bias/inflexibility

In community samples, individuals often deny suicidal ideation, giving it a right skewed distribution. For example, 56% of all individuals (137/244) denied suicidal ideation during the baseline session of Phase 2. The large number of zeros in this distribution may cause commonly employed regression models (e.g., multiple linear regression or Poisson regression) to produce unstable coefficients for predictors, potentially resulting in Type I errors. In order to overcome this disadvantage, research on suicidal ideation (e.g., Chu et al., 2018; Cukrowicz, Jahn, Graham, Poindexter, & Williams, 2013) has begun to employ zero-inflated negative binomial regression models (Greene, 2012; additional information: SI Section S6).

In the present study, zero-inflated negative binomial regression models (implemented via *R's pcsl* package version *1.5.5*) were used to test the portion of *Hypothesis 1* asserting that negative interpretation inflexibility and negative/positive interpretation bias would be uniquely associated with suicidal ideation. Predictors were mean-centered and z-scored. The criterion was left in raw units to maintain its status as a count variable. Bias corrected accelerated (bca) 95% confidence intervals for model coefficients were generated with 1000 re-samples. Data from the

Phase 2 baseline were modeled. Depression was statistically controlled because it associates with interpretation inflexibility and suicidal ideation.

Hypothesis 1 was then tested more fully in these data using network analysis to simultaneously analyze and visualize complex relations between suicidality and its many risk factors (de Beurs, 2017). The network analysis in the present study was conducted in three stages (readers less familiar with network analysis: see SI Section S10).

Network Estimation.

First, network structures were estimated using measures of suicidal ideation, depression, perceived burdensomeness, thwarted belongingness, psychache, defeat/entrapment, hopelessness, certain positive and negative future expectancies, pessimistic repetitive future thinking, perceived stress, positive/negative interpretation bias, and interpretation inflexibility. Partial-correlations were used to calculate edges. The least absolute shrinkage and selection operator (LASSO; Tibshirani, 2016) was used to regularize the resulting network. The tuning parameter for LASSO (λ) was selected to minimize the Extended Bayesian Information Criterion (EBIC; Chen and Chen, 2008), as this technique is beneficial for retrieving the true network structure (Foygel Barber and Drton, 2015). Following the recommendations of Foygel and Drton (2010), the EBIC hyper-parameter (γ) was set to 0.5 to prioritize avoidance of Type I errors. The resulting undirected graphs of regularized partial-correlation networks were visualized using *R's qgraph* package, version *1.6.5* (Epskamp, 2020).

Because network analysis assumes that nodes represent distinct entities (Meier et al., 2019), variables included in each network analyses were evaluated for potential redundancy using *R's networktools* package, version *1.2.2* (Jones, 2020). In keeping with prior research, a given pair of variables was considered potentially redundant if (1) zero-order correlation between

the variables exceeded .70 (indicating at least 50% overlapping variance; following the threshold

adopted in Elliott, Jones, and Schmidt, 2020) and (2) correlations between each member of the

pair and all remaining variables in the network were not statistically significantly different in

more than 75% of cases (Marchetti, 2020; Meier et al., 2019).

Network Inference.

After the network was estimated, node centrality and predictability were examined. Node

predictability was computed using *R's mgm* package, version *1.2.7*. Predictability indexes how

much variance in a given node is explained by the nodes that are connected to it in the network

(Haslbeck and Fried, 2017), and can be understood as an upper bound on controllability (Fried et

al., 2018).

Node centrality was measured using one-step expected influence (in networks with

positive and negative edges, this measure of centrality may be preferable; see: Robinaugh,

Millner, and Mcnally, 2016). One-step expected influence was calculated as the sum of the value

of all edges extending from a given node, taking the mathematical sign of each edge into

account. Expected influence was calculated using *networktools* (Jones, 2020).

Because it is possible that unequal variances of the nodes in the network affect their

centrality estimate, thereby influencing the observed network structure (Terluin, De Boer, and

De Vet, 2016), correlations between expected influence values and standard deviations (SDs) of

the individual nodes were examined. The correlations between expected influences and means of

individual nodes were also examined to better ensure that differences in severity did not explain

node centrality or network structure.

Statistical tests of the differences between edge weights and node centrality measures

were carried out using a non-parametric bootstrapping procedure conducted using *R's bootnet*

package, version *1.3* (Epskamp, 2020). Data were bootstrapped 1000 times for this purpose. If

the 95% confidence interval for the difference between two edge weights or node centrality

metrics did not overlap with zero, the difference was considered statistically significant.

Network Accuracy and Stability.

Network accuracy and stability were also estimated using *bootnet* and 1000 bootstrapped

re-samples. The accuracy of edge weights was quantified using the 95% confidence intervals

generated from this bootstrapping procedure. Narrower confidence intervals indicate greater

precision in edge weight estimates. Stability of centrality measures was quantified using the

correlation stability coefficient (CS-coefficient; Epskamp, Borsboom, and Fried, 2018), which

denotes the proportion of cases that can be dropped such that the set of stability measures

obtained using the full and reduced data-sets are correlated above a certain threshold (.70 in the

present study) with 95% probability. Following the recommendations of (Epskamp et al., 2018),

metrics were considered stable if the CS-coefficient exceeded .25.

Hypothesis 2: Do suicide-related beliefs longitudinally mediate the relation between inflexible/biased interpretations and suicidal ideation?

Hypotheses 1 and 2 were then examined simultaneously in longitudinal data from Phase

2. Specifically, these data were examined to determine whether positive/negative interpretation

bias and interpretation inflexibility were related to future levels of suicidal ideation, and whether

these relations were mediated by beliefs highlighted in major theories of suicide. Path models

were specified using *R's Lavaan* package, version *0.6.5* (Rosseel, 2019). MLR, a variant of the

maximum likelihood approach that is robust to non-normality, was used to estimate parameters

and associated standard errors. Each model (see: SI Section S7) contained negative interpretation

inflexibility and positive/negative interpretation bias as exogenous variables (measured at

baseline), suicidal ideation as an endogenous variable (measured at week 2), and constructs from major theories of suicide (e.g., perceived burdensomeness and thwarted belongingness) along with depression as parallel mediators (measured at week 1). Each path model controlled for baseline levels of the mediator(s), depression, and suicidal ideation. Full information maximum likelihood (FIML) was used to handle missing data (Enders and Bandalos, 2009). Model fits were examined using the following indices (and cutoffs): Comparative Fit Index (CFI; $>.95$), Root Mean Square Residual (RMSEA; $<.06$), Standardized Root Mean Square Residual (SRMR; $<.08$) (Hu and Bentler, 1999). Chi-square statistics were not considered because they tend to over-reject models in the presence of large sample sizes (Bentler and Bonett, 1980). Bias-corrected bootstrapped 95% confidence intervals with 1000 re-samples were generated for all parameters; intervals that do not contain zero indicate significant effects. Indirect effects were deemed significant if Monte Carlo simulation (R's *semTools* package, version *0.5.2,* monteCarloMed function; with 1,000,000 replications) produced confidence intervals that did not contain zero, as recommended by MacKinnon et al. (2002).

Results

Descriptive Statistics

Significant variation in suicidal ideation was observed among participants entering study Phase 2. While the majority of these individuals reported no current ideation (SSI-5=0: 137), a substantial number endorsed at least some ideation (SSI-5=1: 24, SSI-5=2: 24, SSI-5=3: 14, SSI-5=4: 13, SSI-5=5+: 32). The level of suicidal ideation among individuals entering Phase 2 (M=1.51, SD=2.27) lay between that observed in general population samples (M=0.22, SD=0.98; Kliem, Lohmann, Mößle, and Brähler, 2017) and samples of suicide attempters (M=2.18, SD=2.76; Desseilles et al., 2012). Fifty-six Phase 2 participants reported a lifetime history of suicide attempt (186 denied this history). Additional descriptive statistics: SI Table S4.

Zero-order Correlations Between Study Variables

Zero-order correlations between variables were calculated at Phase 2 baseline (SI Table S5). Non-parametric (Spearman's rho) correlations were employed to account for non-normality. Notably, negative interpretation inflexibility was associated with suicidal ideation (rho(242)=.23, $p<.001$), and with several suicide-related beliefs (e.g., perceived burdensomeness, thwarted belongingness, and defeat/entrapment). Negative interpretation bias (rho(242)=.09, $p=.146$) and positive interpretation bias (rho(242)=-.07, $p=.301$) were not associated with suicidal ideation. Despite this, negative interpretation bias was associated with several constructs from prominent theories of suicide (e.g., hopelessness, rho(242)=.20, $p=.001$).

Multiple Regression Models

To examine the portion of *Hypothesis 1* asserting that suicidal ideation would be uniquely associated with interpretation inflexibility and interpretation bias, zero-inflated negative binomial multiple regression models were constructed using data from Phase 2 at baseline. Suicidal ideation was the criterion variable. Interpretation inflexibility, positive/negative interpretation bias, and depression were simultaneous predictors.

As a preliminary analysis, Vuong's test (Vuong, 1989) was used to examine whether a zero-inflated model was merited. Results indicated that this model fit the data better than a standard negative binomial regression model (implemented using *R's MASS* package, version *7.3.51.6*), z=3.18, Pr>|z|=.001. Accordingly, the results of the zero-inflated and count models (Table 1), were interpreted.

The count model indicated that the baseline level of suicidal ideation was 0.81 among individuals with the potential to report ideation (i.e., among potential ideators). Depression and negative interpretation bias were statistically significant predictors of the amount of ideation

reported among these individuals. Model coefficients suggested that there would be a 55% increase (25% decrease) in suicidal ideation if depression increased (decreased) from mean levels to one standard deviation above (below) the sample mean, and that an analogous increase (decrease) in negative interpretation bias would result in a 30% decrease (45% increase) in suicidal ideation. Negative interpretation inflexibility fell just outside the conventional threshold for significance as a predictor of the amount of suicidal ideation reported by potential ideators. Its associated coefficient suggested that increasing (decreasing) negative interpretation inflexibility by one standard deviation from mean levels could potentially result in a 42% increase (32% decrease) in suicidal ideation.

In the zero-inflated model, the intercept was not significantly different from zero (i.e., the baseline odds of not reporting zero suicidal ideation did not significantly differ from 50%). Depression was a statistically significant predictor of whether a case would be an excess zero (non-ideator), while negative interpretation inflexibility again fell just outside the conventional threshold for significance. The coefficients suggested that a one standard deviation increase (decrease) in depression above (below) its mean would portend a 78% decrease (362% increase) in the conditional odds of being a non-ideator. Further, the coefficients suggested that a one standard deviation increase (decrease) in negative interpretation inflexibility above (below) its mean could potentially result in a 38% decrease (62% increase) in the conditional odds of being a non-ideator.

In summary, these results intimate that negative interpretation inflexibility (above and beyond interpretation bias and depression) can predict denial of suicidal ideation and the severity of ideation among potential ideators. As expected, strong evidence emerged that depression also has this predictive utility. Finally, support was found for the notion that negative interpretation

bias has utility in predicting the severity of suicidal ideation among potential ideators. Overall,

these results are consistent with *Hypothesis 1*'s assertion that negative interpretation inflexibility

and negative interpretation bias are uniquely associated with suicidal ideation. These results are

also noteworthy because predictors of whether an individual will deny suicidal ideation can be

useful in clinical contexts as people may have reasons (e.g., social desirability) to deny suicidal

ideation despite experiencing it (Cukrowicz et al., 2013). The present research suggests that

clinicians might be merited in wondering whether individuals who are high on negative

interpretation inflexibility and/or depression may be experiencing suicidal ideation even when

they deny it.

Network Analysis

In order to investigate potential pathways by which inflexible and biased interpretations

may be related to suicidal ideation and the beliefs that putatively inspire it, an undirected partial

correlation network derived from Phase 2 baseline data was examined. Network analysis was

employed because it can simultaneously evaluate relations between all three metrics derived

from the BADE task and beliefs highlighted in multiple theories of suicide, reducing the

probability of Type I errors.

Network Estimation

The goldbricker function (*networktools*) suggested that none of the nodes in the resulting

network (Figure 1) were redundant. Suicidal ideation was positively related to burdensomeness,

depression, hopelessness, psychache, thwarted belongingness, defeat/entrapment, and a lack of

positive future expectations, and was negatively related to positive/negative interpretation bias.

Despite the lack of a direct path between negative interpretation inflexibility and suicidal

ideation, large positive edges connected negative interpretation inflexibility to suicidal ideation

via burdensomeness. Given the nature of partial correlation networks, the presence of these

edges is consistent with the assertion of *Hypothesis 1* that beliefs identified in past theories of

suicide will mediate any relation between interpretation inflexibility or bias and suicidal ideation.

Network Inference

There were several significant differences among edge weights in the network (Figure

S3: top). Notably, edges leading from negative interpretation inflexibility to burdensomeness,

and from burdensomeness to suicidal ideation, were statistically stronger than the majority of

edges. Other edges that were statistically stronger than most others included those between

hopelessness and defeat/entrapment, stress and pessimistic repetitive future thinking, and

depression and psychache.

Significant differences were also observed between nodes' expected influence (SI Figure

S3: bottom). Defeat/entrapment had a statistically greater expected influence than every node.

The expected influences of burdensomeness, psychache, and depression were stronger than the

majority of other nodes. Negative interpretation inflexibility, negative interpretation bias, and

positive interpretation bias had a smaller expected influence than many other nodes in the

network.

There was no correlation between the standard deviation of a node and its expected

influence, rho(12)=.33, *p*=.246. There was also no correlation between node means and their

expected influences, rho(12)=.11, *p*=.716. Thus, the relative average severity of beliefs related to

suicide and differential node informativeness were not capable of explaining the centrality of

nodes in the network.

Variance in nodes was generally well explained by their neighbors. The average

predictability across nodes was .57, indicating that the over half of variance in the network could

be accounted for. However, 43% of the variance in the network remained unexplained and may be attributable to unmeasured variables. Defeat/Entrapment (predictability=.82) was the best explained node in the network, followed by psychache (predictability=.74) and depression (predictability=.70). Approximately half of the variance was accounted for in suicidal ideation (predictability=.52) and negative interpretation inflexibility (predictability=.52).

Network Accuracy and Stability

Bootstrapped confidence intervals suggested that the precision of network edges was acceptable (SI Figure S2). Edges were sufficiently stable, with a correlation-stability coefficient of .67, as was the one-step expected influence (CS-coefficient=.67). Consequently, findings regarding these metrics could be interpreted.

Potential Mediators of Longitudinal Relations Between Interpretation Bias/Inflexibility and Suicidal Ideation

As a further test of *Hypothesis 1*, and to test *Hypothesis 2*, the possibility that the relation between negative interpretation inflexibility and suicidal ideation might be mediated by beliefs highlighted in major theories of suicide was examined in data from the longitudinal portion of the present study. This examination was carried out using three mediation models, each examining potential mediators from a different theory of suicide (while statistically controlling for depression). Only beliefs highlighted in theories employing ideation-to-action frameworks were examined because such theories explicitly identify specific predictors of suicidal ideation (and may better avoid confounding these predictors with those of suicidal behavior).

The first model examined beliefs (perceived burdensomeness and thwarted belongingness) from the Interpersonal Theory of Suicide (Joiner, 2005), along with depression, as potential parallel mediators of the relation between negative interpretation inflexibility (and positive/negative interpretation bias) and suicidal ideation. This model was an excellent fit to the

data: CFI=1, SRMR=.00, RMSEA=.00. The direct path (path a1) from negative interpretation

inflexibility (baseline) to perceived burdensomeness (week 1) was significant, β=0.15, 95%

CI=[0.04,0.25], z=2.70, *p*>|z|=.007. The direct path (path b1) from perceived burdensomeness

(week 1) to suicidal ideation (week 2) was also significant, β=0.25, 95% CI=[0.03,0.48], z=2.18,

p>|z|=.029. When these direct effects were considered jointly, the resulting indirect effect on

suicidal ideation (week 2) was statistically significant, β=0.04, 95% CI=[0.02 0.05]. In contrast,

the indirect effects of negative interpretation inflexibility (baseline) on suicidal ideation (week 2)

via thwarted belongingness (week 1; β=0.00, 95% CI=[-0.01,0.01]) and depression (week 1;

β=0.00, 95% CI=[-0.01,0.01]) were not significant. When controlling for these indirect effects,

the remaining direct effect (path c') of negative interpretation inflexibility (baseline) on suicidal

ideation (week 2) was not significant, β=0.03, 95% CI=[-0.09,0.16], z=0.56, *p*>|z|=.576. The

total effect combining this direct path and the aforementioned indirect pathway via perceived

burdensomeness was significant, β=0.06, 95% CI=[-0.05,0.16]. These results are indicative of an

indirect-only mediation pathway (see: Zhao, Lynch, and Chen, 2010) leading from negative

interpretation inflexibility to suicidal ideation via perceived burdensomeness. Table 2 contains

all remaining parameter estimates.

In accordance with previous studies examining suicidal ideation as an outcome in

mediation analyses (Chu et al., 2018), zero-inflated negative binomial regressions were

examined for consistency with the aforementioned model (SI Section S11). These regressions

provided additional support for the indirect pathway from negative interpretation inflexibility to

suicidal ideation via perceived burdensomeness.

Models featuring beliefs highlighted in the Integrated Motivational and Volitional Model

of Suicidal Behavior (O'Connor, Cleare, Eschle, Wetherall, and Kirtley, 2016; O'Connor and

Kirtley, 2018) and the Three-Step Theory of Suicide (Klonsky and May, 2015) were also

examined. The direct effect of negative interpretation inflexibility on suicidal ideation was

significant in the latter model, and was marginally so in the former model. However, no indirect

effects via beliefs (e.g., hopelessness, defeat/entrapment) relevant to suicidal ideation were

significant. Results obtained using these models are fully described in SI Section S7.

Discussion

The present investigation builds upon previous studies linking interpretation bias to

suicidal ideation (Beard et al., 2017; Beevers and Miller, 2004) by using the emotional BADE

task to simultaneously examine, for the first time, both biased and inflexible interpretations in

relation to suicidal ideation and beliefs highlighted in major theories of suicide. Several key

findings emerged from this investigation: In zero-inflated regression models of cross-sectional

data, negative interpretation bias and (marginally) negative interpretation inflexibility were

associated with suicidal ideation. Network analysis of cross-sectional data revealed a potential

indirect pathway leading from negative interpretation inflexibility to suicidal ideation via

perceived burdensomeness (which, notably, was present in several subgroups of participants,

indicating the robust nature of this result: SI Figures S4-S5). These findings hold even when

statistically controlling for depression, which has previously been linked to inflexible negative

interpretations (Everaert et al., 2018; Everaert, Bronstein, et al., 2020). These results strongly

support the claims of *Hypotheses 1 and 2* with respect to negative interpretation inflexibility, but

provide substantially less support for these claims with respect to interpretation bias.

These results synergize with extant research helping to clarify the relations between

suicidal ideation, perceived burdensomeness, and thwarted belongingness (review: Chu et al.,

2017). Previous studies investigating these constructs indicate that perceived burdensomeness is

the stronger predictor of suicidal ideation (Ma, Batterham, Calear, and Han, 2016). In accordance

with this previous research, the present study found that perceived burdensomeness, but not

thwarted belongingness, was longitudinally related to suicidal ideation. Notably, perceptions of

burdensomeness among suicide ideators are often incorrect (Hames et al., 2013), and may be

systematically distorted by information processing biases (as beliefs often are in the general

population; see: Nickerson, 1998). Consistent with this notion, in the present study a stronger

bias against revising negative interpretations of ambiguous social situations in response to

positive disconfirmatory evidence longitudinally predicted greater endorsement of beliefs

regarding one's status as a burden to others, and, in turn, suicidal ideation. This indirect pathway

was also observed in the psychometric network this study constructed from cross-sectional data.

The identification of this pathway provides the basis for future studies investigating

whether inflexible negative interpretations cause beliefs about burdensomeness to persist,

potentially encouraging interpersonal hopelessness (see: Mandracchia, Sunderland, and To,

2019) and suicidal ideation. Individuals with adverse experiences would be an interesting

population for such studies. Adverse experiences, including discrimination (Sutter & Perrin,

2016), financial hardship (Economou, Angelopoulos, Peppou, Souliotis, & Stefanis, 2016), and

military sexual assault (Monteith, Holliday, Schneider, Forster, & Bahraini, 2019; Wiblin,

Holder, Holliday, & Surís, 2018), have been linked to suicidal ideation. While suicidal ideation

in some individuals with these experiences may be fully driven by entirely accurate beliefs that

are optimally updated, we posit that in many individuals suicidal ideation after adverse

experiences may be exacerbated by insufficient updating of beliefs that do not fully reflect reality

(this theoretical position accords with research suggesting that human cognition is generally

organized to resist belief updating [Altemeyer, 2002; Kaplan, Gimbel, & Harris, 2016],

particularly with respect to personally meaningful beliefs). For example, female veterans who experience military sexual assault may incorrectly blame themselves for their trauma, may falsely believe they are unlovable because of it, and may misperceive themselves as a burden to others, all of which may inspire suicidal ideation (Monteith, Bahraini, & Menefee, 2017; Monteith et al., 2019; Wiblin et al., 2018). Insufficient updating of negative interpretations regarding ambiguous social interactions may lead these inaccurate beliefs to persist (e.g., not updating these interpretations to account for evidence that close others want to help an individual cope with trauma may maintain misperceptions of burdensomeness), and may thereby promote suicidal ideation. Future research should investigate this possibility.

The relations between inflexible negative interpretations, perceived burdensomeness, and suicidal ideation observed here-in may also have clinical implications. Interventions targeting suicidal ideation have sometimes employed cognitive bias modification procedures aimed at altering biased interpretations that may encourage perceived burdensomeness (Allan et al., 2018). The present study suggests that these interventions might be augmented by incorporating modules from other therapies (e.g., the module on changing beliefs from meta-cognitive training for psychosis; Moritz et al., 2014) that likely encourage interpretation flexibility (see: Buonocore et al., 2015).

The present study's results are also relevant to several other theories of suicide. Much of this relevance stems from the fact that the present study, in keeping with previous research examining suicidal ideation (De Beurs et al., 2019), selected variables for its network analysis on the basis of psychological theory. With this in mind, the fact that defeat/entrapment, which forms the backbone of the Integrated Motivational-Volitional Model of Suicidal Behavior (O'Connor and Kirtley, 2018), was the most central node in this network is significant. While the centrality

of defeat/entrapment cannot be interpreted as strong evidence that it plays an important causal role in this network (see: Dablander and Hinne, 2019), it is by definition reflective of the extensive relations between defeat/entrapment and constructs from other theories of suicide (in particular: hopelessness, perceived burdensomeness, and psychache). The existence of these relations should encourage future research examining defeat/entrapment in the context of constructs from other theories of suicide; such research would be extremely beneficial given that studies examining multiple theories of suicide (like the present one) have been exceedingly rare (Kleiman, Law, and Anestis, 2014), but are essential for determining which constructs are causally primary in pathways leading to (suicide and) suicidal ideation.

Beyond their relevance to various theories of suicidality, the present results are notable because they interface with the small-but-growing literature examining interpretation bias in the context of suicidal ideation. Two previous studies on this topic exist. The first found that negative interpretation bias longitudinally predicted suicidal ideation six months later via its effect on hopelessness (Beevers and Miller, 2004), while the second found that a bias against positive interpretations longitudinally predicts suicidal ideation over approximately two weeks (Beard et al., 2017). Both these studies employed psychiatric hospital samples. In the general population sample employed in the present study, however, no evidence of a longitudinal relation between positive/negative interpretation bias and suicidal ideation over two weeks was observed. One potential explanation for the discrepancy between this and previous research is that the effects of interpretation bias on suicidal ideation may take longer than two weeks to become apparent in general population samples (which may feature less severe interpretation bias than samples of hospital patients). Future research investigating the relation between interpretation bias and suicidal ideation in the general population may therefore benefit from a

longer follow-up period. This future research may wish to focus on the bias toward negative (rather than against positive) interpretations, as this bias was more consistently related (cross-sectionally) to suicidal ideation and associated beliefs (e.g., hopelessness) in the present study.

A final noteworthy aspect of the present study is that it is the first to apply a scoring technique to the emotional BADE task that is not based on principal component analysis. Evidence for the validity of this new strategy (which was first applied to the original BADE task in the context of research on psychosis; Sanford et al., 2014) was obtained through the replication of observations from previous studies employing the emotional BADE task (e.g., the relation between negative interpretation inflexibility, dampening of positive emotions, and depression; Everaert et al., 2020), as will be detailed in a forthcoming manuscript. This scoring strategy confers several important advantages. For instance, it allows the emotional BADE task to be employed with small samples, which are incompatible with PCA but common in psychopathology research and clinical settings, and makes comparison of emotional BADE task scores across studies considerably easier. It is therefore expected that the application of this scoring strategy to the emotional BADE task will support continued research on interpretation inflexibility (and bias) in the context of suicidal thoughts and behaviors (and depression and social anxiety; see: Everaert et al., 2018).

These implications of the present study should be considered in the context of several limitations. First, the present study's network analyses were constructed from a cross-sectional dataset and undirected graphs were produced, rendering this study unable to discern the direction of any causal relation between variables in the networks. This limitation is substantially mitigated by the longitudinal models examined here-in. However, in the interest of avoiding Type I error, not every relation present in the network was investigated longitudinally. A second

limitation of the present study is that it examined constructs from important theories of suicide in

relation to a measure of suicidal ideation (the SSI-5) which combines several aspects of

suicidality (e.g., motivational factors, active and passive suicidal desire). Several of these

constructs are theorized to be differentially related to various aspects of suicidality. For example,

the Interpersonal Theory of Suicide specifies that elevated levels of either perceived

burdensomeness or thwarted belongingness should result in passive suicidal ideation, whereas

the presence of both of these variables in addition to interpersonal hopelessness should result in

active suicidal desire (Van Orden et al., 2010). By employing a multifaceted measure of

suicidality, the present study may therefore have underestimated the association between suicidal

ideation and constructs like perceived burdensomeness or thwarted belongingness. In light of this

limitation, future research might adopt more fine-grained measures of suicidality (e.g., measures

focusing either on passive or active suicidal ideation). A third limitation of the present study was

that a comparison of study drop-outs and completers indicated that individuals who completed

the study exhibited less interpretation inflexibility (SI Section S4), raising the possibility that the

results of longitudinal analyses in the present study involving this construct may not generalize

as well to more inflexible individuals. Future research could address this limitation by repeating

these analyses in a sample of individuals likely to exhibit more inflexible interpretations (e.g.,

depressed inpatients).

While not limitations per se, readers should keep two final points in mind when assessing

the implications of this study. First, exploratory analyses detailed in supplementary material (SI

Section S8) indicated that inflexible positive interpretations, like inflexible negative ones, were

related to suicidal ideation (both cross-sectionally and over time) in a manner mediated by

perceived burdensomeness. Accordingly, inflexible interpretations in general, rather than

inflexible positive or negative interpretations specifically, may be the most relevant to suicidal ideation. Second, data for the present study were collected during the early phases of a global pandemic and participants may have been subject to measures (e.g., physical [and social] distancing) meant to protect public health (for details on the timing of data collection and an extended discussion of the potential effects of this context, see SI Section S1). Because the effects of these measures and the pandemic itself on the relations between variables in the present study are unclear, it is possible that this study's results might not generalize perfectly to populations free from such stressors, though this study's replication of research conducted prior to the pandemic (see: SI Section S1) tempers this concern somewhat. If future research reveals that pandemics and/or their associated public health measures result in unique relations between variables relevant to suicidal ideation, then the present study affords a unique window into these relations that may prove valuable, particularly because pandemics and their sequalae (e.g., quarantine) have been linked to increases in experiences associated with suicidality (e.g., stress and depressive symptoms; Liu et al., 2012).

Conclusion

Despite these considerations, the value of the present study is apparent against the backdrop of data (e.g., the fact that suicide causes more than 800,000 deaths per year [Kestel and Van Ommeren, 2019], and is not strongly predicted by established risk factors in most existing research studies [Franklin et al., 2017]) implying that our current understanding of suicide is inadequate for the development of sufficiently effective suicide-prevention strategies. To the extent that identifying causes of suicidal ideation can inform interventions on suicide (see: Jobes & Joiner, 2019), the present study may help ameliorate this tragic situation through its suggestion that inflexible interpretations may encourage beliefs regarding burdensomeness and, in turn,

suicidal ideation. By identifying this potential mechanistic pathway, the present study may also scaffold improvements upon existing treatments targeting suicidal ideation, which is strikingly common (Jobes & Joiner, 2019) and can cause distress and functional impairment (Van Spijker et al., 2014), even in the absence of suicidal behavior. Moreover, the present study is valuable because it is the first to simultaneously examine biased and inflexible interpretations in relation to suicidal ideation and because it provides exciting new directions for research examining how beliefs highlighted in prominent theories of suicide might be distorted by biases in information processing, like the bias against revising interpretations in response to evidence against them.

Author Contributions

J. Everaert and M.V. Bronstein developed the study concept, which J. Joormann and E. David Klonsky helped to refine. All authors contributed to the study design. M.V. Bronstein collected the data. J. Everaert and M.V. Bronstein drafted the manuscript. T.D. Cannon, J. Joormann, and E. David Klonsky provided critical revisions. All authors approved the final manuscript for submission.

Acknowledgements

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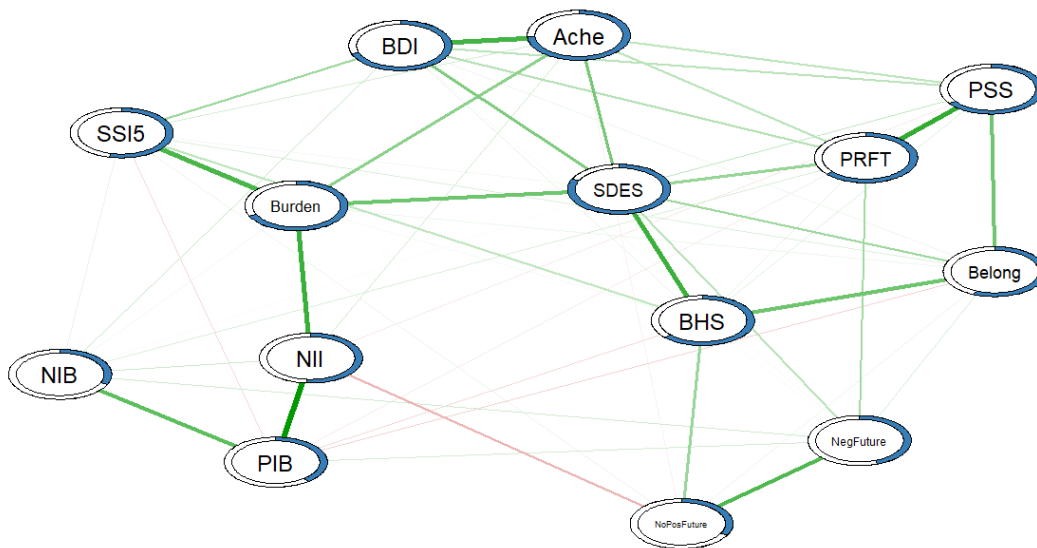
Figure 1. Regularized partial correlation network. Annulus surrounding each node denotes predictability (more filled=more predictable). SSI=Scale for Suicide Ideation. Ache=Psychache. BDI=Beck Depression Inventory. PRFT=Pessimistic repetitive future thinking. PSS=Perceived Stress Scale. SDES=Short Defeat and Entrapment Scale. Burden=Burdensomeness. BHS=Beck Hopeless Scale. NII=Negative Interpretation Inflexibility. NIB=Negative Interpretation Bias. PIB=Positive Interpretation Bias. Belong=Thwarted Belongingness. NoPosFuture=Confident anticipation of lack of positive future events. NegFuture=Confident anticipation of negative future events.
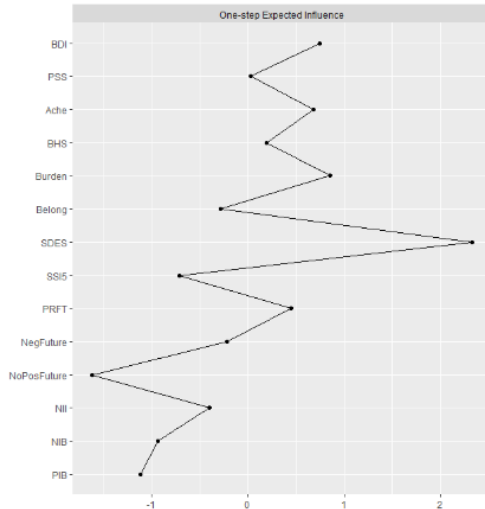
Figure 2. Centrality measures (one-step expected influence) of nodes in regularized partial correlation network. SSI=Scale for Suicide Ideation. Ache=Psychache. BDI=Beck Depression Inventory. PRFT=Pessimistic repetitive future thinking. PSS=Perceived Stress Scale. SDES=Short Defeat and Entrapment Scale. Burden=Burdensomeness. BHS=Beck Hopeless Scale. NII=Negative Interpretation Inflexibility. NIB=Negative Interpretation Bias. PIB=Positive Interpretation Bias. Belong=Thwarted Belongingness. NoPosFuture=Confident anticipation of lack of positive future events. NegFuture=Confident anticipation of negative future events.

Table 1.

Zero-inflated negative binomial regression model with suicidal ideation as the criterion

variable: results for disconfirming-the-negative scenarios.

Negative binomial regression (count model)	Estimate [95% bca CI]	SE	Z	Pr > |z|	Odds Ratio
Predictor					
NII	0.14 [-0.04 0.25]	0.08	1.82	.070	
NIB	**-0.20 [-0.35 -0.01]**	**0.08**	**-2.38**	**.017**	
PIB	-0.12 [-0.25 0.07]	0.08	-1.53	.123	
BDI	**0.40 [0.19 0.52]**	**0.08**	**4.83**	**< .001**	
Intercept	0.81 [0.70 1.10]	0.11	7.20	< .001	
Logistic Regression (zero-inflation model)					
NII	-0.48 [-0.94 0.07]	0.25	-1.93	.054	0.62
NIB	-0.06 [-0.56 0.53]	0.24	-0.23	.817	0.94
PIB	0.28 [-0.24 0.82]	0.24	1.17	.243	1.32
BDI	**-1.53 [-1.91 -0.92]**	**0.30**	**-5.08**	**< .001**	**0.22**
Intercept	-0.12 [-0.37 0.51]	0.25	-0.48	.629	

Note. NIB=negative interpretation bias. PIB=positive interpretation bias. NII=negative

interpretation inflexibility. BDI=[Beck] Depression [Inventory] (item #9, which asks about

suicidal thoughts/wishes, was omitted to avoid redundancy with the SSI-5). All variables were

measured during the baseline session of study Phase 2.

Table 2

Longitudinal Mediation Model: Interpersonal Theory of Suicide

Criterion	Predictor	Estimate [95% CI]	SE	z	P > |z|
Regressions					
SI (week 2)	NII (baseline)	0.03 [-0.09 0.16]	0.06	0.56	.576
	NIB (baseline)	0.01 [-0.07 0.09]	0.04	0.32	.750
	PIB (baseline)	0.02 [-0.08 0.11]	0.05	0.37	.712
	PB (week 1)	**0.25 [0.03 0.48]**	**0.12**	**2.18**	**.029**
	TB (week 1)	-0.09 [-0.25 0.06]	0.08	-1.21	.225
	SI (baseline)	**0.63 [0.47 0.78]**	**0.08**	**7.83**	**< .001**
	PB (baseline)	-0.06 [-0.29 0.17]	0.12	-0.55	.583
	TB (baseline)	0.04 [-0.11 0.20]	0.08	0.53	.597
	BDI (baseline)	-0.02 [-0.35 0.31]	0.17	-0.11	.911
	BDI (week 1)	0.18 [-0.11 0.47]	0.15	1.23	.220
PB (week 1)	**NII (baseline)**	**0.15 [0.04 0.25]**	**0.05**	**2.70**	**.007**
	NIB (baseline)	0.02 [-0.04 0.09]	0.03	0.69	.488
	PIB (baseline)	0.02 [-0.08 0.11]	0.05	0.30	.762
	SI (baseline)	0.08 [-0.02 0.17]	0.05	1.58	.114
	PB (baseline)	**0.66 [0.56 0.77]**	**0.05**	**12.77**	**< .001**
	TB (baseline)	0.02 [-0.06 0.10]	0.04	0.47	.640
	BDI (baseline)	**0.12 [0.00 0.23]**	**0.06**	**2.00**	**.046**
TB (week 1)	NII (baseline)	-0.01 [-0.11 0.09]	0.05	-0.14	.892

	NIB (baseline)	0.00 [-0.11 0.09]	0.04	0.00	.999
	PIB (baseline)	-0.09 [-0.18 0.00]	0.05	1.95	.051
	SI (baseline)	-0.07 [0.16 0.02]	0.05	-1.59	.112
	PB (baseline)	0.10 [-0.01 0.22]	0.06	1.73	.085
	TB (baseline)	**0.77 [0.69 0.85]**	**0.04**	**17.98**	**< .001**
	BDI (baseline)	0.07 [-0.04 0.19]	0.06	1.24	.215
BDI (week 1)	NII (baseline)	-0.01 [-0.10 0.08]	0.05	-0.23	.821
	NIB (baseline)	0.03 [-0.05 0.10]	0.04	0.64	.522
	PIB (baseline)	-0.04 [-0.13 0.05]	0.04	-0.88	.380
	SI (baseline)	-0.02 [-0.13 0.09]	0.05	-0.38	.703
	PB (baseline)	0.08 [-0.02 0.18]	0.05	1.53	.126
	TB (baseline)	0.01 [-0.06 0.09]	0.04	0.40	.692
	BDI (baseline)	**0.84 [0.74 0.93]**	**0.05**	**16.79**	**< .001**

Intercepts					
SI (week 2)	--	0.00 [-0.08 0.07]	0.36	-0.11	.915
PB (week 1)	--	0.02 [-0.04 0.08]	0.03	0.59	.556
TB (week 1)	--	0.01 [-0.07 0.08]	0.04	0.13	.894
BDI (week 1)	--	0.02 [-0.04 0.09]	0.03	0.72	.471

Note. SI=Suicidal Ideation. TB=Thwarted Belongingness. PB=Perceived Burdensomeness. NII=Negative Interpretation Inflexibility. NIB=Negative Interpretation Bias. PIB=Positive Interpretation Bias. BDI=[Beck] Depression [Inventory]. **BOLD=**significant. The model described in this table is visualized in SI Section S7.