

Can Personal Electronic Communications Identify Suicide Risk in Real Time?

Jeffrey Jonathan Glenn
Aiea, Hawaii

B.A., Stanford University, 2003
Ed.M., Harvard Graduate School of Education, 2011
M.A., University of Virginia, 2014

A Dissertation Presented to the Graduate Faculty
of the University of Virginia in Candidacy for the Degree of
Doctor of Philosophy

Department of Psychology

University of Virginia
August 2018

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Abstract

Suicide is a serious public health problem and a leading cause of death around the world. Despite its tragic toll on society, our methods for identifying individuals when they are at highest risk of suicide remain ineffective. As such, objective tools to dynamically assess level of suicide risk are sorely needed to determine not just who but *when* someone is at imminent risk of killing themselves. The proliferation and ubiquity of mobile phone text messaging offers a promising avenue for gaining insight into possible novel, real-time markers of suicidal behaviors. In this pilot investigation, we utilized a within-subject, laboratory-based research design to identify and better understand real-time patterns in communication unique to periods preceding suicide attempts when suicide risk is especially high.

Individuals reporting a history of suicide attempt ($N=33$) were recruited from the Psychology Department's participant pool and the UVA/Charlottesville community. After collecting their phone text messaging data (SMS), participants were asked to retrospectively identify and describe past suicide attempts, as well as periods of suicide ideation, depressed mood, and positive mood. An automated language analysis software package (LIWC) was then used to produce scores for each text message capturing five psychological constructs of interest: self-focus, sentiment, social engagement, time-orientation, and cognitive performance. Within-subjects analyses were performed to test whether these characteristics differed in general (mean differences) and over time (slope differences) just before a suicide attempt (high risk), relative to other periods when participants had suicidal thoughts but did not attempt (moderate risk), or were depressed but not suicidal or during periods of positive mood (low/minimal risk).

In terms of overall mean differences, results indicated that high suicide risk was associated with messages indicating greater anxiety, sadness, and orientation towards or focus on

the future, as well as more complex and higher-status communication, though these language features did not uniquely and consistently differentiate suicide attempts from other episodes. In terms of differences in patterns *over time*, high suicide risk was associated with language indicating greater increases over time in self-focus, elaborated fluency, and orientation towards the future, though, as with mean differences, pairwise comparisons between episode types were mixed. Most notably, however, results suggested that anger increased and positive emotion decreased to a greater extent as one approached a suicide attempt, relative to the other episode types, potentially providing unique markers of high suicide risk.

Overall, these results indicate that personal electronic communication has the potential to provide clues into the suicidal mind and offer temporally sensitive markers of suicide risk. Specifically, emotional content of language (and anger in particular), when examined over time, may represent unique psychological features indicative of high suicide risk. In the short term, findings from this study may be utilized to construct machine learning models that attempt to *predict* acute suicide risk. In the long term, such predictive models may serve as the basis for developing objective tools to determine level of suicide risk in real time and provide at-risk individuals the help they need before they attempt suicide.

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Acknowledgements

The completion of a project of this sort is only possible by virtue of a long, winding developmental process, shaped over the course of many years by innumerable individuals to whom I feel a deep sense of gratitude. I would like to acknowledge several by name.

First, I would like to thank my advisor, Bethany Teachman, for her steadfast and generous support throughout this journey. In addition to her prowess and productivity as a clinical scientist, the commitment and generosity she consistently demonstrates as an advisor, supervisor, and mentor to her students are astonishing, and I admire and am grateful to her. I have benefited from her collaborative spirit and appreciate the risks she takes to work with experts outside of our field, which is the only way a project like this was possible. I appreciate her willingness to serve as my clinical supervisor in my fifth year, despite having no obligation to do so, simply because I asked and wanted to learn as much from her as I could.

I would like to thank Alicia Nobles, my collaborator and co-recipient of the UVA Data Science Fellowship, the program that brought us together in the first place. This project was truly a joint effort the entire way through, and I feel proud to have worked closely and persevered together with her over countless working sessions at Shenandoah Joe's, Atlas Coffee, and JSF. Her energy and ingenuity continue to inspire me and I cannot wait to see what is in store for her career. I am grateful to Laura Barnes for the effort and resources she devoted to this ambitious project. Thank you to my dissertation committee members, Eric Turkheimer and Joe Allen, for their insights and feedback. I am grateful to have had the help of many wonderful research assistants over the years, each to whom I owe a debt of gratitude: Megan Amos, Somil Chugh, Annie Friddell, Nha-Han Pham, Tara Saunders, Austin Smith, Abbie Starns, Austin St. John, and Gina Vuu.

I am grateful to the entire PACT lab family for supporting me instrumentally and emotionally along this journey. I am blessed to have worked with a group of such smart, interesting, and committed individuals, including: Jessica Beadel, Miranda Beltzer, Elise Clerkin, Meghan Cody, Christina Emeh, Gena Gorlin, Jen Green, Karl Fua, Ann Lambert, Erin Maresh, Josh Magee, Nauder Namaky, Sam Portnow, Meg Reuland, Shari Steinman, Alex Werntz, and Diheng Zhang. A special thank you to Phil Chow for his friendship and support during times when I needed it most. I am grateful to my awesome clinical cohort for their camaraderie and support: Diana Dinescu, Alison Nagel, and Joey Tan.

I want to thank Matt Nock for sparking my interest in suicide research and giving me my start in this field through his mentorship. I still cannot believe I went up to him after the first day of class in 2010 and asked him for a job in the lab (not generally my style) but I am sure glad I did. I am grateful to past and current members of the Nock Lab who have served as wonderful colleagues and friends over the years, including: Christine Cha, Julia Harris, Adam Jaroszewski, Evan Kleiman, Mark Knepley, Alex Millner, Nicole Murman, and Katarina Slama. Thank you to Karthik Dinakar for sparking my imagination in predictive modeling and the potential for fruitful psychology-engineering collaborative ventures.

Thank you to the Presidential Fellowships in Data Science program at UVA, especially Phil Trella, for supporting this research, providing numerous professional development opportunities, and fostering interdisciplinary spirit among the fellowship cohort. Thank you to the Center for Open Science for providing statistical consulting resources. I am incredibly grateful to the Research Data Services team at UVA Library, especially Clay Ford and Michele Claibourn. They offered me unbelievable support throughout my entire graduate career and

equipped me with the statistical and programming skills to pull this off. Thank you, Clay, for answering every single one of my desperate emails.

I would like to thank my family and friends for their love and support over many years. Thank you to my childhood friend and rock star clinical psychology researcher, Chad Ebesutani, for inspiring my interest in this field and being so generous with his time and expertise to help out a fledging clinical scientist. Thank you to my parents, Norm and Gail Glenn, for their unending support of my career and life choices; my brother and his family, Chris Glenn, Sarah Sharp, Kenzo and Noemi Glenn-Sharp; my extended family on both sides; and my Hawaii “calabash” family. Thank you to the Deming family for their love and support and for providing a restorative respite for us in the Blue Ridge Mountains and beyond: Doug and Julia Deming; Kaylyn and Kush Banerjee; and Douglas Deming. Thank you to my sweet little kitty and miracle CASPCA rescue, Marlowe. Lastly, thank you from the bottom of my heart to my wonderful wife, best friend, and occasional co-author, Charlene Deming.

Introduction

Suicide is a serious public health problem and a leading cause of death around the world. In fact, more deaths occur by suicide than by all other interpersonal violence, including war and homicide, combined (World Health Organization, 2009). In the United States, suicide is responsible for over 41,000 deaths each year, making it the 10th leading cause of death (Centers for Disease Control and Prevention, 2014). Tragically, suicide is the 2nd leading cause of death among individuals 15-24 years of age and accounts for over 1,000 deaths at U.S. colleges and universities every year (Centers for Disease Control and Prevention, 2014). Despite growing awareness of and research into suicide, rates today are very similar to those from the 1950s (Centers for Disease Control and Prevention, 2014), indicating a critical need for better ways to identify and intervene with individuals at risk of suicide. Using a novel within-subjects design, the current study sought to analyze personal text messages (Short Message Service; SMS) of suicide attempters and identify patterns uniquely indicative of acute suicide risk (i.e., communication patterns immediately preceding suicide attempts vs. during periods of suicide ideation only or no ideation). To this end, we aimed to improve our ability to assess suicide risk dynamically in real time.

Need for Better Identification of Acute Suicide Risk

Given the staggering toll suicide takes on society, it is surprising that our methods for identifying when individuals are at highest risk of suicide remain ineffective. One reason for this is that suicide researchers over the past several decades have focused primarily on identifying *general* risk factors for suicide. For instance, it is well established that being young, male, single, and White or Native American, and having a prior psychiatric diagnosis and history of self-harm are all factors that confer greater risk of future suicide death (Centers for Disease Control and

Prevention, 2014; Nock, Hwang, Sampson, & Kessler, 2010). As a result, our ability to identify groups of individuals at risk is relatively impressive for a significant yet relatively rare clinical outcome. Using data from the World Health Organization, a recent study found that a model including known risk factors for suicide attempt accounted for 80.3% of the variance (Nock, Borges, & Ono, 2012). However, such general risk factors fail to tell us *when* someone is at greatest risk of suicidal behaviors. In other words, even if we know which individuals may be most vulnerable, we currently lack the tools to assess if or when that individual will take action to attempt to kill him- or herself. By comparing multiple periods of high vs. low suicide risk, all within a sample of suicide attempters, the current study attempted to trace how suicide risk changes *dynamically* to better understand proximal risk for a suicide attempt.

Our chief method for assessing acute or short-term suicide risk remains clinicians' judgments, which, unfortunately, have been shown not to accurately predict future suicidal behaviors (Nock, Park, et al., 2010). There are a number of reasons why clinical judgment in predicting suicide is poor. Difficulty in assessing risk stems from the near universal reliance on self-report, which is highly problematic for several reasons. Those at greatest risk may be motivated to conceal their thoughts (e.g., to avoid or gain release from hospitalization). In fact, one study found that 78% of inpatients denied suicidal thoughts during the last verbal communication they had prior to killing themselves (Busch, Fawcett, & Jacobs, 2003), and only 30% of eventual attempters disclosed their suicidal ideation beforehand (Kovacs, Beck, & Weissman, 1976). In addition, people may lack the ability to accurately assess the factors impacting their current risk. Thus, there is an urgent need for novel, data-driven tools to assess acute suicide risk.

In light of these challenges, recent work has sought to use behavioral tools to overcome problems associated with self-report. For example, researchers have attempted to identify objective markers of suicide risk using tools such as the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998) and the modified Stroop task (Cha, Najmi, Park, Finn, & Nock, 2010). Several studies have suggested that the IAT, for example, can improve the prediction of future self-harm above and beyond other well-known predictors (e.g., prospectively predict future suicide ideation; Nock, Park, et al., 2010). The current study sought to take a similar behavioral approach via a within-person examination of electronic personal communications. This approach can help avoid the complications inherent to either patient or clinician self-report and moves away from traditional between-subjects comparisons, in which many features distinguish people who have versus have not attempted suicide (beyond just suicide attempt status) given one can obviously not randomly assign participants to a given suicide attempt status.

Novel Approaches Needed to Study Low Base Rate Behaviors

Despite frequent calls to develop better ways to identify risk of serious suicidal behaviors, researchers studying suicide face tremendous methodological challenges, several of which we addressed in this study. First, suicidal thoughts and behaviors have low base rates, which makes it difficult to obtain sample sizes large enough to prospectively predict future suicidal behaviors. To illustrate the problem, one recent study estimated 12-month presence of suicide attempt for adults at 0.3% (Borges et al., 2010), which would mean that at least 300 unselected individuals would be required to produce a single suicide attempt during a one-year follow-up period. Further complicating this problem is the fact that the progression to a suicide attempt (e.g., decision making and planning associated with a suicide attempt) usually begins

less than a week prior to the attempt (Millner, Lee, & Nock, 2016), suggesting the critical period to examine is very narrow. By reconstructing the timeline of recent suicidal behaviors through a retrospective clinical interview, we utilized a *prospective* research design to understand which features in text communications predicted suicide attempt, overcoming the power issues of a ‘true’ prospective study design.

Second, the problem in suicide research is that the subjects of greatest interest – suicide completers – cannot be directly studied (Millner, Lee, & Nock, 2015). Therefore, researchers must rely on individuals with non-lethal forms of suicidal thoughts and behaviors. Due again to low base rates, many studies use less severe forms of self-harm, such as suicide ideation, to serve as outcome measures. For example, many studies with multiple time points assess suicide ideation, as opposed to attempts or completions, at follow-up (e.g., Miranda & Nolen-Hoeksema, 2007). The shortcoming of this approach is that prior research suggests that risk factors associated with suicide ideation differ from those of more serious suicidal behaviors, such as suicide attempts (May & Klonsky, 2016; Nock, Hwang, et al., 2010). By recruiting only individuals with a history of *acting* on their suicidal thoughts (i.e., actual suicide attempts), or on the cusp of acting on their thoughts (i.e., aborted or interrupted suicide attempts), this study focused on those behaviors most strongly associated with and predictive of suicide completion.

Rise of Electronic Text Data

The rising use of smart phones and content-sharing services, such as email, blogs, crowd-source review sites, and social networks, has resulted in a proliferation of textual data (Cambria, Schuller, Xia, & Havasi, 2013; Kagan, Rossini, & Sapounas, 2013). Textual, or unstructured, data provide a rich source of information that can be analyzed to extract characteristics of the individual. For example, the field of sentiment analysis utilizes data mining and natural language

processing to capture an author's intended sentiment (e.g., attitude, opinion, or emotional state) from subjective textual data. Such analytic approaches have recently garnered the attention of the mental health community, including suicide researchers. Recent studies have focused on using text analytic approaches on clinical notes to determine long-term predictors for suicide (Hammond & Laundry, 2014; Kagan et al., 2013) and emotions predictive of suicide (Pestian, Matykiewicz, & Linn-Gust, 2012; Pestian, Matykiewicz, Linn-Gust, et al., 2012; Sohn et al., 2012; Yang, Willis, De Roeck, & Nuseibeh, 2012). Key findings include that early childhood abuse reported in clinical records predicts suicide attempts and that computer algorithms are more accurate than clinicians in distinguishing genuine from fake suicide notes.

Again, however, such approaches are better suited to tell us *who*, not *when*, someone is at risk. In this study, we collected participants' phone text messaging data and examined this use of language *over time*, allowing for insight into how communication patterns changed as an individual drew closer to their suicide attempt (Gunn & Lester, 2012). We used a tool developed by James Pennebaker – Linguistic Inquiry and Word Count (LIWC; Pennebaker, Boyd, Jordan, & Blackburn, 2015) – to analyze various properties of text communications. LIWC searches a text file and calculates word counts for over 2300 words that have been previously categorized into a number of linguistic and psychological dimensions. Private electronic communication was an ideal source of data for suicide research because it provides ecologically valid data that accumulates automatically and is thus resistant to biases common to the research process, such as demand characteristics or efforts at impression management. This was also the first study, to our knowledge, to collect and analyze private text messaging data for suicide (or any other clinical outcome).

Communication Features of Interest: Self-Focus, Sentiment, Social Engagement, and Cognitive Deconstruction (Time Orientation and Cognitive Performance)

The main objective of this study was to test whether features of text messaging data could identify and differentiate increasingly severe levels of suicide risk. We tested both whether these characteristics differed in general (mean differences) and over time (slope differences) between periods of high suicide risk (prior to suicide attempts) versus those of lower suicide risk (in decreasing order of risk, suicide ideation, depressed mood, or positive mood). The subset of communication characteristics we focused on were chosen based on theoretical interest and prior research supporting their relevance in suicide-related outcomes.

First, one theory of suicide posits that suicide is a means to escape from negative self-focus (Baumeister, 1990). It follows that the feedback loop of increasing self-focus and painful recognition of self-failures may lead someone to act on their suicidal thoughts as a means of escape. Indeed, previous research has shown that suicidal individuals tend to be more self-focused in their communication. One study found that poets who completed (vs. did not complete) suicide relied on first-person pronouns to a much greater extent (Stirman & Pennebaker, 2001). Furthermore, in transcribed verbal interviews with suicidal and control adolescent inpatients, usage of first-person pronouns was significantly higher for suicidal, compared to control, participants (Venek, Scherer, Morency, Rizzo, & Pestian, 2014). In the current study, we tested whether usage of first-person pronouns (as an indicator of self-focus) was greater prior to suicide attempts, compared to episodes of suicide ideation, depressed mood, or positive mood.

Second, prior research has identified depressed affect (Bulik, Carpenter, Kupfer, & Frank, 1990), hopelessness (Hawton, Casanas, Haw, & Saunders, 2013; Smith, Alloy, &

Abramson, 2006), and anxiety (Nock, Deming, et al., 2012) as important risk factors for suicide, suggesting that individuals at suicide risk may use language expressing these emotions at higher rates and with greater negative valence. In support of this idea, use of positive and negative emotion words in transcribed verbal interviews were significantly different among suicidal adolescent inpatients compared to controls (Venek et al., 2014). In this study, we tested whether attempt episodes demonstrated significantly greater use of negative emotion words and less use of positive emotion words (as indicators of negative sentiment). We also tested whether attempt episodes involved greater use of words related to the concept of death.

Third, according to the interpersonal theory of suicide (Joiner, 2005; Van Orden et al., 2010), suicide may result from feelings of perceived burdensomeness and thwarted belongingness. In theory, social support should combat such feelings and increase feelings of connectedness. Previous research examining between-subjects differences in perceived social support indirectly supports this hypothesis. In a study of Twitter users, currently suicidal, compared to non-suicidal, individuals reported significantly less belongingness and higher burdensomeness (Braithwaite, Giraud-Carrier, West, Barnes, & Hanson, 2016). In another study, perceived social support from family was lower for hospital emergency department patients with (vs. without) a past suicide attempt (Thompson, Kaslow, Short, & Wyckoff, 2002). In the current study, we tested whether suicide attempters demonstrated greater signs of disengagement from and burdensomeness on their social support networks prior to suicide attempts compared to other episodes by examining patterns in outgoing vs. incoming messages.

Lastly, despite an absence of direct empirical evidence, there are theoretical reasons to believe that individuals in highly suicidal states may exhibit changes in future orientation and cognitive performance. According to his theory of suicide, Baumeister (1990) argues that

suicidal thinking is characterized by “cognitive deconstruction” (p. 99), or the constriction of one’s psychological perspective, which includes both a narrowing in time perspective to the present moment and a focus on concrete sensations over abstract ideas. We tested whether language indicating a particular time orientation (e.g., focus on the past, present, or future) and level of cognitive performance (e.g., language exhibiting more analytical thinking) varied by episode type.

Overview and Hypotheses

In this pilot investigation, we proposed a novel way of utilizing private electronic communication to identify unique textual patterns that occur in advance of suicide attempts and during periods of heightened suicide risk. Specifically, we asked participants with a history of suicide attempt to retrospectively identify and characterize different periods of their lives – suicide attempts, suicide ideation, depressive episodes, and periods of positive mood – and then compare whether and in what ways their text messages from periods of acute suicide risk (preceding a suicide attempt) differed from other periods of moderate (suicide ideation) or minimal/no suicide risk (depressed/positive mood). We analyzed and compared episodes within person based on a number of features selected *a priori* and tested not only for overall mean differences between episodes but also differences in change *over time*. In this way, we aimed to combine a rich dataset of electronic communication and quantitative text analytic methods with laboratory research methodology to address a critical public health problem, in the service of improving our ability to assess and identify suicide risk in real time.

Although no studies to date have examined text messaging content or any other private (i.e., not publicly available) electronic personal communications, we had several hypotheses based on the psychological theories of suicide previously discussed. Using a within-subjects

approach, we hypothesized that characteristics of text messaging content during periods of higher suicide risk would differ from those of lesser risk. Specifically, messages prior to a suicide attempt would demonstrate increased self-focus (i.e., greater singular first-person pronoun usage), greater negative emotional content (i.e., greater frequency of negative affect words, in general and specifically related to anxiety, anger, and sadness, and lesser frequency of positive affect words), and decreased social engagement (i.e., lower ratio of sent vs. received text messages). We also hypothesized that attempt episodes would demonstrate increased present-oriented language and reflect reduced cognitive performance (i.e., several variables capturing properties of language complexity and sophistication), though these hypotheses were drawn only from theory and not prior empirical research.

Numerous aspects of this research were exploratory by nature. Given the lack of prior research examining *when* one might expect any differences to emerge prior to a suicide attempt, we did not have hypotheses on whether language differences would be observed for episodes overall (means) but not changes over time (slopes), or vice versa. We also did not have hypotheses about the pattern of any observed differences among episode type comparisons, such as whether differences would be unique to suicide attempts (differentiated from all other episode types) or shared between suicide attempt and ideation episodes (differentiated only from depressed and positive episode types). As such, we tested a few alternative episode comparison groupings to see whether these would change any effects. We also tested whether results would differ when using data subsets of only certain types of episodes (e.g., including only enacted/actual vs. aborted or interrupted suicide attempts), or only messages with individuals with whom the participant had a close relationship. These additional approaches were taken due to the possibility that language differences might only emerge under certain conditions, such as

when severity of suicide attempt episodes were especially high or in communication with individuals with whom participants would be willing to be emotionally expressive.

In this study, we aimed to utilize ecological personal data to gain insight into possible novel, real-time markers of suicidal behaviors. By better understanding how language differs and changes as suicide risk increases, it may eventually become possible to develop more accurate and objective tools to determine level of suicide risk in real time and get individuals the help they need before they attempt suicide.

Methods

Participants and Recruitment

A sample of 33 participants with at least one reported past suicide attempt were recruited from the Psychology Department's participant pool and from the UVA/Charlottesville community (via craigslist and posted flyers around the community). To reach the target recruitment of the lab study, 2,377 individuals were screened online and 77 individuals were screened by phone. (See Figure 1 for a CONSORT diagram detailing specific numbers and reasons for exclusion.)

Materials

Pre-lab study screeners.

Online screening surveys. Participant pool participants were selected based on two surveys (see Appendix B for the full screening surveys). On the participant pool pretest administered at the beginning of the semester (Survey 1), participants were asked, "Have you ever had a period of sadness in the past during which you felt hopeless?" and, if so, were then asked whether they would like to be contacted about possible participation in studies that ask more questions about this period of time in their life. Those who said yes to both pretest

questions were emailed a link to an additional two-question survey (Survey 2). Survey 2 began with a notice informing individuals that the research was on sensitive topics, including the desire to hurt or kill oneself, and that researchers sought to learn from people's experiences to ultimately improve suicide prevention and care. The survey then asked, "Have you ever made a suicide attempt?" and "Have you ever had thoughts of wanting to kill yourself?" Those endorsing a past suicide attempt were emailed and invited to participate in a phone screen to determine if they qualified for the study.

To recruit additional participants, the recruitment flyer and craigslist ad for community participants asked about the presence of a past suicide attempt and instructed interested individuals to contact the lab via email or phone to set up an appointment to complete a phone screen. Therefore, these participants did not need to complete Screening Survey 2 online. Given the ad asked specifically about a past suicide attempt and it was therefore likely most callers would have made a past suicide attempt and thus would require a risk assessment, only the principal investigator completed these calls.

Phone screen. The purpose of the phone screen was to provide potential participants with more information about the study and to ensure inclusion criteria were met. Inclusion criteria included: (1) confirmation of group status based on report of past suicide attempt; (2) adult status (≥ 18 years-old); (3) availability of and access to personal messaging data dating back prior to significant life events (e.g., suicide attempt); and (4) minimal or no current desire to die (i.e., less than or equal to 5 on a 0-10 Likert scale and no current suicide plan or intent). Any participants with intense thoughts of suicide who were determined to be at "high risk" or "imminent risk" for suicidal behavior (as determined by a suicide risk assessment instrument) were excluded from study participation and referred for clinical care. Given we were interested in collecting and

analyzing text communications made prior to suicidal or other events, participants were excluded if they did not have access to at least one data service type (e.g., text messages, Facebook) dating back to before their most recent suicide attempt.

Phone screens of individuals with a previous suicide attempt, as indicated on the screening survey, were administered by the principal investigator, who was trained and supervised by his faculty advisor, Dr. Bethany Teachman.

Communications data collection and storage. Participants downloaded their communication data in the lab with the experimenter's assistance, which ensured transparency throughout the process. Once data had been downloaded to the laboratory computer, additional steps were taken to secure these data and upload them to a secure server.

Specific data sources. SMS text message data from iPhone and Android phones were accessed using third-party software or phone applications. Specifically, participants with iPhones were instructed to download their SMS text messages using software programs called *iExplorer*, *SynciOS Manager*, and *SynciOS Data Recovery*, and those with Android devices were instructed to download their messages using Android mobile apps called *SMS Backup & Restore* and *SMS to Text*. Participants were asked to bring into the lab as many devices as they thought might contain electronic data (e.g., laptop, older phones) and all available SMS data from each device were downloaded (i.e., not from only certain dates or recipients). Sample download instructions for participants are included in Appendix C. Additional forms of personal electronic data, including phone call history, Google data (Gmail, Hangouts/Gchat messages, and Chrome browser history), Facebook messages, and Twitter messages, were collected for the purposes of future analyses but are not part of the current study.

Data storage. During and immediately after the participant finished the study, the raw downloaded text data were stored temporarily on a password-protected desktop computer in the lab. Given that the content of the data was unknown (e.g., the communication likely contained personal information or health information combined with a HIPAA identifier), within a week, these data were transferred to and stored on ES3, a secure server operated by UVa ITS and intended for the secure storage of sensitive (e.g., health) information. UVa Identity Token authentication technology was utilized to ensure that the original downloaded data transferred to and from ES3 were encrypted and restricted to the investigators in this study. After text data had been moved to ES3, any initial data downloaded from various communication platforms remaining on the local lab computer were deleted and wiped from the hard drive. This data storage plan was reviewed and approved by the IRB.

Frequent recipients. Participants were asked to list the names of people to whom they most frequently sent messages with emotional content (i.e., top 10 recipients) and then were asked to categorize their relationship with that person (e.g., family, friend, school/work colleague, mental health professional). Later, when the raw text data were cleaned, each recipient's name was replaced by a code referring to relationship type (e.g., parent). This contact information was later used to subset the text data collected in order to examine how the number and content of messages sent during periods of high suicide risk differ depending on the social support role of the person with whom the participant is communicating. See Appendix D for the instructions and an example item.

Interview and episode identification. The goal of the laboratory-based interview was to learn about past suicidal and non-suicidal events in greater detail so that electronic communication made during and/or just prior to these events could later be compared using text

analytic techniques. During the interview, participants were asked to identify a number of specific events or episodes in the past and the calendar dates during which the episodes took place. Episodes included: 1) past actual, interrupted, or aborted suicide attempts, using the two-week period prior to the attempt as a “suicide attempt episode”; 2) two-week episodes of suicide ideation (not resulting in a suicide attempt); 3) two-week episodes of depressed mood or high stress (not resulting in suicide ideation or attempt); and 4) two-week episode of positive mood (i.e., more positive mood than usual and no ideation or attempt). (Note that reported ‘suicide attempts’ also included incidents in which no physical attempt was enacted but in which participants considered their planning or actions to constitute a higher level of suicidality than ‘suicide ideation’ so they subjectively endorsed making an attempt on the screener questions.) The decision to set each episode at two weeks long was made in a conservative effort to capture the critical period of increased ideation, planning, and intent leading up to a suicide attempt; preliminary analyses were later performed to determine whether a narrower time window (i.e., shorter than two weeks) would better capture this high-risk state. A total of 3-12 episodes were collected for each participant depending on the presence and number of reported events. For each episode type, we asked about a maximum of three episodes (e.g., three suicide attempts if participant has three or more lifetime attempts). Interviews took 1-2 hours to complete.

Critically, classifications of these reported episodes became the basis of the study’s within-subjects design, with episode type serving as our main predictor variable and language characteristics of text messages during the episodes as the outcome variables. In terms of suicide risk levels, attempt episodes were considered “high risk”, ideation episodes were considered “moderate risk,” and depressed and positive episodes were considered “minimal/no risk.”

Episode-specific questionnaires (answered for each individual episode). In addition to reporting specific dates during which the target episodes occurred, participants were also asked to provide specific details of and context surrounding their reported episodes. Given research showing that suicidal behaviors are sometimes misclassified based on single-item questions (Millner et al., 2015), these additional questions were asked for each behavior type to minimize the risk of misclassification. Abbreviated versions of the following measures were administered for each event/time period (see Appendix E for the specific set of interview questions):

Suicidal thoughts and behaviors. Questions from a number of well-validated measures were used to assess specific details about suicide attempts (i.e., presence of actual, interrupted, and/or aborted attempts, method, intent, subjective and objective lethality, and planning) and suicide ideation episodes (i.e., presence of active and/or passive ideation, frequency, duration, and intensity). These included the Self-Injurious Thoughts and Behaviors Interview (SITBI; Nock, Holmberg, Photos, & Michel, 2007), the Columbia-Suicide Severity Rating Scale (C-SSRS; Posner et al., 2011), the Suicide Intent Scale (SIS; Beck, Schuyler, & Herman, 1974), and the Beck Scale for Suicidal Ideation (BSS; Beck, Kovacs, & Weissman, 1979).

Depression and anxiety symptoms. Depressive symptoms were assessed for each identified episode using items from the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996) and the Patient Health Questionnaire-4 (PHQ-4; Kroenke, Spitzer, Williams, & Löwe, 2009).

State mood. An abbreviated 6-item version of the Positive and Negative Affect Schedule (PANAS; Watson & Clark, 1994) was used to measure positive and negative affect and asked participants to rate the intensity of affect for several different types of emotions. Participants

completed a separate PANAS for each episode, reporting how they remembered feeling, on average, at the time.

General questionnaire battery (answered once during the study). Participants completed a number of general questionnaires at the end of the study, which were used to characterize the sample and were not tied to specific episodes (see Appendix G for the full set of questionnaires)¹:

Demographics information. Participants provided information about their age, gender, race/ethnicity, citizenship, education, marital status, employment status, and living situation.

Mental health and treatment history. The Mental Health History and Treatment Questionnaire was used to assess current and past treatment experience (e.g., medications, therapy) and psychiatric diagnoses. Some items related to symptom history were adapted from the screener sections of the World Health Organization World Mental Health-Composite International Diagnostic Interview (WHO WMH-CIDI; Kessler et al., 2004; World Health Organization, 2014).

Suicidal thoughts and behaviors. The Self-Injurious Thoughts and Behaviors Interview (SITBI; Nock et al., 2007) was used to assess participants' history of self-injurious thoughts and behaviors. Participants were asked to rate the presence and frequency of each behavior (i.e., non-suicidal self-injury, suicide ideation, suicide plan, suicide attempts, subset of suicide attempts requiring medical attention) within the past month, the past year, the past three years, and lifetime.

¹ A number of additional questionnaires were administered, including online communication habits, Depression Anxiety Stress Scales (DASS), modified Positive and Negative Affect Schedule (PANAS), Beck Hopelessness Scale (BHS), Revised Life Orientation Test (LOT-R), Modified Future Self Scales (MFSS), and Multidimensional Scale of Perceived Social Support (MSPSS). However, given the focus of our study on understanding within-subjects differences, we did not include these questionnaires into the inferential analyses. These scale scores are available on request from the author.

Procedure

Participants were invited into the laboratory for one 2- to 2.5-hour session to complete several tasks. First, participants were instructed to download their private data sources (e.g., SMS) and list 5 to 10 individuals with whom they communicate most frequently and/or were emotionally close. Second, participants were interviewed by the experimenter and asked to identify a number of episodes, including past suicide attempts (and interrupted or aborted attempts) and two-week episodes of suicide ideation, depressive mood, and positive mood. Participants were then asked to describe specific details of and context surrounding each time period. Lastly, participants completed several questionnaires (e.g., demographics, suicide history). To view a timeline indicating when all measures were administered, please see Appendix A. In the rare instances in which the data download process that participants initiated had not finished by the conclusion of the lab session, participants were given the option of returning to the lab for a 5-10 minute follow-up visit during which they were assisted in downloading any outstanding data to the laboratory computer.

Risk Assessment

Prior research indicates that asking young adults with previous suicide attempts about suicide does not cause an increase in psychological distress or increased suicidal thoughts or behaviors, either immediately following an assessment (Gould et al., 2005) or several years after an assessment (Reynolds, Lindenboim, Comtois, Murray, & Linehan, 2006). This has been shown to be true even when showing individuals with a history of suicidality fairly graphic images (e.g., cut skin; Cha et al., 2016). In fact, one research study found that depressed participants asked about and exposed to suicide-related content actually demonstrated *reductions* in suicide ideation (Smith, Cukrowicz, Poindexter, Hobson, & Cohen, 2010). Therefore, we did

not anticipate participants would experience an increase in suicidal thoughts. However, as a precautionary measure, participants were asked two questions regarding negative mood and desire to die both at the beginning and at the conclusion of the lab session to assess any changes as a consequence of the interview and study visit. Those who significantly increased in negative affect or suicidality (i.e., any increase of 2 points or greater on the 0 to 10 negative mood and desire to die rating scales) and/or were elevated in current suicidality (i.e., score greater than 3 on desire to hurt self question) were administered a formal suicide risk assessment by the PI and assigned a risk level based on their answers. The protocol was that those considered at “moderate risk” would be assisted in developing a “safety plan,” or a series of steps to take to keep one safe when feeling suicidal; those considered at “high risk” or “imminent risk” of suicide would be asked to provide a contact number and immediately contacted by the faculty advisor, Dr. Teachman, a licensed clinical psychologist (though no participants ended up being at high or imminent risk).

Plan for Analyses

Data Preparation and Scoring. Given the format of SMS data differed between iPhone and Android phones, participants’ SMS data files were individually cleaned using a Python script that restructured the data to standardize the encoding of messages and naming of variables across all participants. The individual data files containing only the SMS data were then matched and merged with participant and episode information collected during the lab study. For example, labels were added to each individual text message indicating whether it belonged to an identified episode and, if so, the type and certainty of the date(s) of the episode, and on which day it fell within the given episode. In addition, names and phone numbers of individuals that participants selected as communicating with frequently and/or being especially close were matched to

correspondents in individual messages, and the relationship (i.e., family, friend, or significant other) was then assigned to that message.

Each individual SMS message was inputted into and scored using the 2015 version of Linguistic Inquiry and Word Count (LIWC), a language analysis software package that calculates numeric values based on the properties of the text (Pennebaker et al., 2015). The majority of LIWC variables calculate scores based on the proportion of words belonging to a given category (e.g., score of 60.0 indicates 60% of words in the message belonged to the given category); other LIWC variables include counts of words (e.g., word count of message, words per sentence) and several proprietary, “non-transparent” variables (e.g., Analytic, Tone). After all this information was appended, the individual SMS files were then compiled and identifying information (e.g., message content, sender/recipient names, phone numbers) were removed prior to analysis.

Preliminary Analyses. Preliminary descriptive analyses on demographic information, mental health and suicide history, and other information pertinent to the primary analyses (e.g., iatrogenic effects of the lab study) were performed on the sample of participants contributing at least one episode of messaging data. Analyses were also performed in aggregate by episode type, comparing attempt, ideation, depressed, and positive episodes on certainty of identified dates, presence and intensity of suicidal thoughts, depression and anxiety symptoms, and mood, as reported by participants regarding each individual episode. This comparison of episode characteristics served to establish validity of classification of episodes, which were based on single-item responses (e.g., presence of past suicide attempt), and to illustrate episode type similarities and differences in greater detail.

Plan for Temporal Visualizations: When does language change as a suicide attempt

nears? Descriptive within-subjects plots were constructed to illustrate how communication features change as a suicide attempt nears. Five psychological constructs, with corresponding linguistic constructs and specific features, were examined: 1) self-focus, 2) sentiment and suicidal content, 3) time orientation, 4) cognitive performance, and 5) social engagement (see Table 4 for the full set of language variables falling under each psychological construct).

Temporal visualizations consisted of line graphs plotting the features by day for 30 days before and after suicide attempts, using mean scores across all eligible participant data by day. To decrease the influence of between-subjects differences, scores on each outcome variable were within-subject standardized by individual participant, creating ipsatized z-scores (Hicks, 1970). Such figures visually showed if and how features changed as one approached a suicide attempt event and were used to empirically inform the decision on the appropriate time window to use for subsequent analyses (e.g., all 14 days vs. only 7 days prior to suicide attempts).

Plan for Primary Analysis 1: Does language differ between episode types? We performed inferential analyses to examine within-subject (between-episode) differences among suicide attempters using several communication features. In these analyses, we focused on testing differences between suicide attempt and other episode types for the five previously discussed psychological constructs given our interest in understanding if and how communication patterns differ across episodes and whether there are language patterns unique to being in an imminent suicidal state. Specifically, a series of mixed-effects models were performed with episode type as a within-subject fixed effect (4 levels: attempt, ideation, depressed, positive) and the language feature of interest as the outcome variable. A random by-participant slope for episode type, and random intercepts of participant, participant-episode (or “episode,” which is different from “episode type”), and message were included as the random

effects. Likelihood-ratio (Wald chi-square) tests were performed to compare goodness of fit for models including and excluding the fixed effect of episode type; a significant test is conceptually similar to an omnibus test for a predictor in an ANOVA and therefore indicates whether the inclusion of the fixed effect significantly improves model fit. Any significant tests were followed up with pairwise comparisons between each of the episode types (using z and t statistics for binary/proportion and continuous outcome variables, respectively). Mixed-effects models do not yield straightforward effect size statistics like other regression models (e.g., R^2) and there is not a consensus on the most appropriate approach to take (see Peugh, 2010). Here, β (standardized values of the model parameter estimates in log odds units) are reported and serve as effect sizes. To determine the effect of a predictor on an outcome variables (e.g., the effect of attempt episode, relative to ideation episode, on self-focus), one could simply exponentiate β to yield the odds ratio.

Data for Analysis 1 were originally analyzed using mixed effects models that included a single random effect (i.e., random intercept/slope of participant). This original analytic approach was revised to specify a more robust random effects structure based on conceptual concerns that the original models did not adequately account for random variability throughout the full nested structure of these data (i.e., participant, episode, and message level variability). Results from the original analytic approach are available upon request.

Advantages of mixed-effects models. This mixed-effects method was selected over more traditional repeated-measures ANOVA approaches because of its well-established advantages in terms of producing more accurate effect estimates and its ability to handle missing data, non-normal outcome data, and unbalanced classes (Baayen, Davidson, & Bates, 2008; Dixon, 2008; Jaeger, 2008). Using mixed models allowed us to account for variability among participants,

episodes, and messages, leading to more accurate and generalizable population estimates for within-subject effects of episode type and resolving non-independence of the nested data. This approach also allowed us to maximize sources of variance by analyzing on the message level rather than only mean values by episode, and was especially appropriate for this dataset given the amount of ‘missing data’ (i.e., participants varied widely in terms of the number of episode types they reported and for which they had text data). By taking into account random effects tied to between-subject differences, mixed models allowed us to retain all episodes in our analyses.

Selection of random effects. In terms of the process of selecting random effects, researchers have handled these decisions in different ways. Although intercepts-only models are commonly used in psychological literature, Barr and colleagues (2013) and others have recommended using the maximal random effects structure when performing confirmatory analyses as a means to boost generalizability of the findings and protect against inflated Type I error rates common in underspecified (e.g., intercepts-only) models. In this case, the maximal model justified by the data were random intercepts of participant, episode, and message (or day, if the lowest level of data was day instead of message), and random by-participant slopes for episode type. This set of random effects was selected because our dataset included multiple levels of nesting (i.e., messages nested within episodes, and episodes nested within participants), meaning that a model needed to account for potential non-independence of observations at each level. Data-driven model comparisons varying the random effects included are sometimes used in model selection as a means to determine the best-specified set of random effects, in terms of balancing goodness-of-fit and model complexity (Baayen et al., 2008; Matuschek, Kliegl, Vasishth, Baayen, & Bates, 2017). However, we decided to specify our models using a purely theoretically-driven approach given a desire to maximize the generalizability of our findings and

because our analysis entailed primarily hypothesis testing as opposed to more exploratory approaches (Judd, Westfall, & Kenny, 2012). Models were fitted using the “lme4” package in R (Bates, Maechler, Bolker, & Walker, 2014; R Core Team, 2013) and specified in R as:

```
outcome ~ episode type + (1 + episode type | participant)
          + (1 | episode) + (1 | message)
```

In our dataset, each ‘message’ was given a code that was unique across, not just within, participant-episodes, which was done to make explicit the nesting structure of our model. Likewise, each ‘participant-episode’ was given a code that was unique across, not just within, participants. If the data were similarly nested but codes had only been unique within (vs. across) levels, lme4 syntax would be specified as: (1 | episode/message). These approaches are computationally equivalent.

Specification of outcome variables in the models. One complication for these data was that our various outcome variables varied in their expected distributions. For example, because many of the LIWC scores are proportions (i.e., percentages of total words belonging to a given category), these variables would not be normally distributed, a core assumption of linear models and necessary to minimize bias in error estimates. Indeed, when running linear models using raw LIWC proportion scores as the outcome variables, model residuals were not normally distributed. We considered a number of alternative analytic approaches to account for this expected distribution. Beta regression is a modern approach for dealing with proportions as outcome variables (Cribari-Neto & Zeileis, 2010). However, such functions did not allow for easily entering random effects in the model, which was too great of a tradeoff to make given between-subject variability. We also considered applying a logit or arcsine-square-root

transformation to the proportion scores to correct for normality concerns before applying a linear mixed model; however, these transformations have been shown to produce spurious results (Jaeger, 2008) and, in our data, did not improve normality among the model residuals.

The final approach, which we ultimately used, was to examine the data on the *word* level, rather than as proportion scores by *message*, to create discrete, binomial variables. By multiplying the LIWC score by the word count of the message, we could create yes/no counts for whether each word belonged to a given category. We then used this binomial data in generalized linear mixed models (GLMMs; Breslow & Clayton, 1993), which is essentially logistical regression that takes into account random effects. The advantage of using a GLMM was that we could account for the actual number of words appearing in a category rather than rely simply on the proportion score, which would not capture differences in message length. This also resolved the problem of having non-normally distributed outcome variables (Agresti & Kateri, 2011; Jaeger, 2008). Indeed, the resulting plots of the model residuals appeared normally distributed.

Model functions in R. GLMMs used the `glmer` function in R specified with a logit link function appropriate for binomially distributed data, which transformed parameters into log-odds units. The estimated regression coefficients produced were on a log scale. For this set of analyses, a significant result says that the odds of a category-specific word appearing in text messages differed as a function of episode type. For outcome variables that were not proportion scores (e.g., number of messages sent per day), the raw continuous variable was used in a linear mixed-effects model (LMM), using the `lmer` function.

Plan for Primary Analysis 2: Does language approaching a suicide attempt change differently over time relative to language changes during other episode types? Like the first set of analyses, the second set focused on testing for differences between suicide attempt

episodes and other episode types but by examining differences in *changes in communication over time* rather than by overall mean difference between episode types. The purpose of this second set of analyses was to examine whether communication changed differently during the 14 days leading up to a suicide attempt compared to changes during other two-week periods for episode types of lower suicide risk (for which there is no theoretical expectation of temporal change). A series of mixed-effects models were performed for each language feature with 3 fixed effects: episode type (4 levels: attempt, ideation, depressed, positive), day of episode (numerical factor ranging from -14 to 0), and the interaction of episode type and day. The maximal random effects model appropriate for these data included random intercepts of participant, episode, and message, and random by-participant slopes of episode type, day of episode, and episode type by day. Models with the full set of random slopes did not converge; therefore, only a by-participant slope of episode type was included in the final model, which was specified in R as:

```
outcome ~ episode type * day of episode + (1 + episode type |  
      participant) + (1 | episode) + (1 | message)
```

Although episode type and day were included as fixed effects in the models, we were only interested in the interaction term given we evaluated episode type separately already and did not have a theoretical interest in time as an independent variable. The same procedures were used to evaluate goodness-of-fit of the fixed effects and pairwise contrasts for any significant interactive effects between attempt by time and other episode type by time interactions. Similarly to Analysis 1, models from Analysis 2 were revised from their original approach (i.e., single random effect of participant) to specify a more robust random effects structure that includes

variables at each level of the nested structure (i.e., participant, episode, and message). Results of the original analyses are available upon request.

Supplementary Analyses. Additional analyses were performed to examine the same set of outcome variables but in different ways to see if the pattern of results changed. The same mixed-effects models were run in the following ways: 1) including only the subset of episodes that participants rated as being ‘very certain’ about their selected dates; 2) using only the most serious suicide attempts, during which the attempt was enacted (vs. interrupted or aborted); 3) using only the subset of messages exchanged with people identified as being very close; 4) including only the subset of days before the suicide attempt during which the most change in variables occurred (as informed by the earlier descriptive temporal analyses); 5) changing the grouping comparison to suicidal (i.e., attempt or ideation) versus not suicidal (i.e., depressed or positive); and, 6) changing the grouping comparison to suicide attempt versus all other messages, including all other episode types and messages not labeled with an episode.

Multiple Comparisons Considerations. The multiple comparisons problem is a potential concern when running a large number of tests and can increase the chances of rejecting the null hypothesis due to the sheer number of tests being run. In such cases, some researchers use a multiple testing correction, such as familywise error rate-controlling procedures like the Bonferroni correction, which divides the p value needed to achieve significance by the number of tests performed. In the current study, we decided against the use of a multiple comparisons correction for several reasons. First, multiple testing correction assumes independent tests, and given many of our outcome variables are attempting to capture the same construct (e.g., multiple variables used to capture emotion), they are theoretically associated with one another and likely not independent. Many of the supplementary tests were also variations of a primary model (e.g.,

same model on a different subset of data) and therefore also not independent. Second, our analyses of language characteristics focused on only two basic models (two different sets of predictors), and pairwise comparisons were only performed when the main effects of interest were significant, reducing the total number of tests performed. Third, using the maximal (or near-maximal) random effects in our models likely decreased the chances of Type I error and therefore may already be sufficiently conservative; prior research has argued that maximal random effects structures can be overly conservative and lead to a significant loss of power (Matuschek et al., 2017). Lastly, given this is a pilot study with a small sample and the fact that we did not have concrete directional hypotheses for many of the tests, we decided not to artificially suppress Type I error and rather view any significant results in light of these caveats (Rothman, 1990).

Sample Size and Power Considerations for Mixed-Effects Designs. To produce proper estimations of power for hierarchical designs in which data are nested (i.e., suicide episodes are nested or clustered by participant), it is necessary for analyses to take into account the ‘design effect,’ which is how much the clustering alters the effective sample size. The more clustering present (i.e., a small number of participants with a larger number of episodes), the smaller the effective sample size will be as compared to the actual sample size, resulting in less power to detect effects. Therefore, if a traditional power analysis specifies a sample size of i episodes as necessary to detect a given effect size, it will need to be multiplied by the design effect to determine the actual (larger) sample size required (Kish, 1965). In this study, we used a very conservative estimate for the design effect to calculate effective power as described below.

The formula for the design effect is $1 + (n - 1)p$, where n is the number per cluster (in this case, the average number of episodes per person, since person is the clustering variable), and

p is the intra-class correlation (ICC), which is the between-person variance (σ_b^2) divided by the total variance (sum of between-person and within-person variance; $\sigma_b^2 + \sigma_w^2$). In this case, we expected n to equal 2 based on preliminary data collection (i.e., 2 suicide attempts per attempter). The ICC equals the between-subject variance divided by the total variance. If the ICC is close to zero, this means the clusters are quite similar (i.e., suicide attempters as a group communicate very similarly). Such a case would result in a design effect of 1, which essentially means the sample size needed would be the same as those produced by traditional power analyses. When the ICC is close to one, this means the clusters are quite dissimilar, and thus, the variation *between* cluster means (i.e., between participants) is much higher than the variation *within* the clusters (i.e., between episodes). The ICC, represented by p , is more difficult to estimate given we lack prior evidence to guide the extent to which between-subjects vs. within-subjects variance will account for the total variance. In a study using LIWC to analyze NIH grant application critiques, the highest ICC reported by the researchers across LIWC variables was 0.41 (Kaatz, Magua, Zimmerman, & Carnes, 2015). Therefore, we estimate that an ICC of 0.8, nearly twice as high, is a very conservative estimate. This is essentially saying that between-subjects variance (i.e., differences between attempters) will account for 4 times the amount of total variance as within-subjects variance (i.e., differences within attempters between episodes). In effect, this reduces the statistical value of each additional attempt beyond the first one for a given attempter. Based on these parameters, the design effect is equal to 1.8, which was used to inform estimates of achieved power given the sample size.

One complication of this study is that we anticipated only being able to collect text data for 1 out of 3 suicide attempt episodes. Reasons for this include text data not reaching far enough back in years to capture prior attempts, especially for non-recent attempts, or the lack of

availability of text data at all. Therefore, effective power based on episodes was further reduced. Given the large effect sizes reported in a number of studies examining some of the same LIWC variables, such as self-focus ($d=1.06-1.31$; Stirman & Pennebaker, 2001; Venek et al., 2014), sentiment ($d=0.88-1.21$; Venek et al., 2014), and constructs related to social engagement, such as belongingness ($d=1.52$; Braithwaite et al., 2016), we conducted a power analysis based on the assumption of large effect sizes. We determined that a sample size of 30 suicide attempters (representing 60 attempts but only 20 with collected, usable SMS data, divided by the design effect) would provide enough power to detect only large effect sizes (Cramer's $V=0.29$) for chi-square tests of mixed-effects models comparing suicide attempts to other types of episodes, assuming 80% power and a significance level of .05. Therefore, it should be noted that the study was underpowered to detect small- or medium-sized effects and therefore prone to Type II error. Also, even among those variables for which there is theoretical reason to expect large effects, most of this research relied on between-subjects, rather than within-subjects, designs. Thus, it was unknown whether previously observed effect sizes would hold when comparing within-subject episodes.

Results

Preliminary Analyses

Sample characteristics. As shown in Table 1, 33 participants reported having made a past enacted, interrupted, or aborted suicide attempt. Most of the participants were female, White, and college-aged. As expected based on recruitment criteria, all participants reported a history of at least one actual/enacted, interrupted, or aborted suicide attempt (about 80% reported making an actual suicide attempt) and about half reported a history of non-suicidal self-injury. The majority of participants reported having struggled with a mental health problem during their

lifetimes, and a little over half reported having a diagnosis; most commonly a mood and/or anxiety disorder.

Episode characteristics. As shown in Table 2, a total of 293 episodes were collected across all participants. Slightly more episodes were reported for non-suicidal (i.e., depressed/positive mood) compared to suicidal (attempt/ideation) periods. Among the episodes queried during the lab interview, 134 (46%) episodes contained SMS data, collected from 27 different participants. Among these 27 participants, 15 had data from at least one reported suicide attempt; the other 12 participants contributed data from non-suicide attempt episodes and were still included in the analyses. Participants reported and had SMS data for on average approximately 1.5 episodes for each episode type. Across all episodes, 189,478 text messages were collected and analyzed, ranging between on average about 1,200-1,600 text messages per episode. Participants were generally confident about the accuracy of the dates they selected, rating 90.3% of episodes as ‘very certain’ (i.e., exact days) or ‘somewhat certain’ (i.e., may be off by a few days).

Descriptive characteristics of different episode types. Episode type comparisons were performed on various characteristics to establish validity of the classification of episodes (which were initially based on answers to single questions) and to identify other factors that could inform interpretation of the study’s primary results. Analyses revealed that participants did not significantly differ in terms of how certain they were of their selected dates as a function of episode type, $\chi^2(6, N=119)=10.74, p=.097$. Consistent with expectations, severity of episode type (severity refers to extent of possible suicidality in this case, so attempts are considered most severe, followed by ideation, depressed, and positive) is associated with greater active suicide ideation presence (reporting ‘Yes’ to the question “During these two weeks, did you think of the

following for longer than a few minutes (more than fleeting thoughts): *Maybe I should kill myself*"), $\chi^2(6, N=83)=142.63, p<.001$; however, the difference between attempt and ideation episodes was only marginally significant ($p=.065$). Severity of episode type was also associated with greater intensity of suicide ideation (reported on a 5-point scale to the question "During this two-week period of having suicidal thoughts, how intense or severe were your thoughts of wanting to kill yourself?") at the worst point of the episode, $F(2, 80)=163.90, p<.001$, and on average, $F(2, 80)=121.30, p<.001$; attempt episodes were greater than ideation episodes ($ps=.001-.010$), and ideation episodes were greater than depressed episodes ($ps<.001$) (ideation was not assessed for positive episodes). These results indicate that attempt episodes entailed greater reported severity of suicide ideation than ideation episodes, in line with the expected elevated level of suicide risk, although it is important to note these reports of ideation were given retrospectively and should thus be interpreted with caution.

In terms of depression and anxiety symptoms and state mood (reported retrospectively for each identified episode using the PHQ-4 and the abbreviated PANAS, respectively), depression presence differed by episode type, $\chi^2(6, N=119)=82.27, p<.001$, but attempt and ideation episodes were similar ($p=.892$), and both were higher than depressed episodes but not to a significant degree ($ps=.062-.102$). Depression severity was greater for attempt episodes compared to depressed ($p=.024$) and positive mood ($p<.001$) but not significantly different from ideation episodes ($p=.338$), and ideation episodes did not differ from depressed ($p=.164$). Anxiety severity and negative mood both followed a similar pattern except ideation episodes, in addition to attempts, were significantly different from depressed episodes ($ps=.001-.046$). These results indicate that mood and anxiety symptoms follow the expected pattern across severity of

episode types but that attempt, ideation, and depressed episodes generally do not vary a lot from one another on these factors.

Descriptive characteristics of suicide attempts. Additional descriptive information about reported actual, interrupted, or aborted suicide attempts was collected to better understand the methods used and circumstances leading to the attempts, as well as to validate that the level of suicidal intent and lethality associated with the attempts was high (see Table 3). Among attempters with SMS data, 13 participants reported a single lifetime attempt and 14 reported multiple ($M=1.74$, $SD=0.86$). Among the 21 attempts with corresponding SMS data, the most common methods reportedly used or considered/aborted were medications/overdose (43%), hanging/suffocation (38%), and jumping from a height (24%). Based on participants' description of the objective lethality of the attempt, 29% of incidents involved some action being taken in which some physical harm was caused (e.g., taking a higher than normal dose of medication, resulting in nausea and light-headedness) while 71% of incidents did not result in any physical harm (e.g., driving to high place, such as a bridge, but deciding not to jump). Notwithstanding the low rates of actual physical harm, participants reported fairly high intent to kill themselves ($M=3.95$, $SD=0.86$) and subjective judgment of the lethality of the suicide method was reasonably high ($M=3.38$, $SD=0.86$), confirming the serious nature of the attempt episodes. Further, a specific suicide plan (i.e., time and place) was present for most of the attempts (76%). Academic or job stress (29%) and problems with friends or with relationship partners (29%) were the mostly common endorsed primary reasons that contributed to the attempts. Less than half of participants (43%) reported having received treatment from a psychiatrist, psychologist, or licensed mental health counselor during the two weeks prior to the suicide attempt while

slightly more participants (48%) reported that they received professional treatment during the two weeks following the attempt.

Iatrogenic effects. Examining possible iatrogenic effects of the study, reported mood from pre ($M=6.33$, $SD=1.38$) to post ($M=6.12$, $SD=1.17$) did not significantly change, $t(32)=1.05$, $p=.304$, and desire to die from pre ($M=0.82$, $SD=1.10$) to post ($M=0.61$, $SD=0.90$) significantly decreased slightly, $t(32)=2.23$, $p=.033$.

Results of Temporal Visualizations: When Does Language Change As A Suicide Attempt Nears?

Given the lack of research to suggest how psychological factors change as someone increases in suicide risk state, it is not known whether and when language use might shift approaching a suicide attempt. Given our interest in determining whether language differed between episode types, it was important to see when the most change occurs in case our selected default period duration (i.e., 14 days) was too long or short to capture the meaningful changes. To assess this question empirically, temporal visualizations were constructed for each variable of interest and consisted of graphs plotting daily means for the given variable during the 30 days prior to and following the attempt (see Figure 2 for an example). Given the considerable variability among these daily means, a smoother (loess) function was used to approximate change over time, and visual inspection was used to identify the period prior to the suicide attempt when the rate of change was most pronounced. Although these periods varied between variables, it appeared that changes often occurred around 7 days prior to the suicide attempt across all variables. Accordingly, this 7-day period was used in subsequent secondary analyses to examine whether the effects of differences across episode types became stronger using this narrower time window versus the original 14-day window.

Results of Primary Analysis 1: Does Language Differ Between Episode Types?

When testing whether language use was associated with episode type, analyses revealed no significant fixed effect of episode type for variables reflecting self-focus. However, there were several consistent patterns when examining language use related to sentiment, social engagement, time orientation, and cognitive performance. (See Table 5 and 6A-E for full results.)

Regarding *sentiment*, there was a significant effect of episode type on use of sad words, $\chi^2(3)=8.74, p=.033$. Pairwise comparisons revealed that attempt episodes were significantly higher in sad words compared to ideation ($z=2.64, p=.008$), but not compared to depressed or positive mood ($z_s=1.07-1.09, p_s=.277-.285$) (Figure 3B²). There was also a significant effect of episode type for anxiety, $\chi^2(3)=8.66, p=.034$, though it should be noted these effects were present only when restricting analyses to “certain” episodes (i.e., the subset of episodes participants reported as being “very certain” about their selected dates). In this case, attempts contained a higher proportion of words indicating anxiety compared to positive mood ($z=2.56, p=.011$), though the comparison did not reach statistical significance when attempts were compared to ideation ($z=1.81, p=.070$), and use of anxiety words did not significantly differ between attempt and depressed mood episodes ($z=1.33, p=.185$) (Figure 3A). No significant effects by episode type emerged for more general emotional content (i.e., positive emotion, negative emotion, emotional tone) or other specific emotions/constructs (i.e., anger, death).

² The effect plots for Analysis 1 each use a given model to estimate proportions of words at each episode type level and display a confidence interval (CI) around those estimates. Bootstrapped asymmetric CIs (based on 0.025 and 0.975 percentiles) were used instead of normal symmetric CIs (based on the normal distribution) in order for the plots to agree with the modeling output. This approach to plotting was necessary because effects were small, and more traditional CIs reflect differences within each level of episode type as opposed to within-person differences between episode types, which is the focus of this analysis).

Regarding *social engagement*, there was a significant effect of episode type on two of the four variables examined, including number of outgoing messages, $\chi^2(3)=12.92, p=.005$, and number of incoming messages, $\chi^2(3)=9.10, p=.028$, but only when “certain” episodes were included in both sets of analyses. Pairwise comparisons revealed that participants sent significantly more messages per day during depressed episodes compared to positive episodes ($z=3.50, p<.001$); however, participants did not send significantly more messages per day during attempt episodes compared to any other episode types ($zs=0.01-1.60, ps=.110-.999$) (Figure 4A). This same pattern for the average number of outgoing messages per day was also observed for incoming messages, such that a greater number of messages were received during depressed episodes compared to positive episodes ($z=3.07, p=.002$), but no significant differences between attempt and other episodes were observed ($zs=0.31-1.91, ps=.056-.754$) (Figure 4B). No significant effects by episode type emerged when examining differences in the ratios of number of sent vs. received words or number of sent vs. received messages.

Regarding *time orientation*, there was a significant effect of episode type on future orientation, $\chi^2(3)=9.73, p=.021$, such that attempt episodes showed greater future orientation than ideation ($z=2.30, p=.021$), though the comparison did not reach statistical significance when attempts were compared to depressed mood ($z=1.89, p=.059$), and the difference between attempt and positive mood was not significant ($z=0.31, p=.756$) (Figure 5). No significant effects by episode type emerged for past or present orientation.

Regarding *cognitive performance*, there was a significant effect of episode type on language complexity, $\chi^2(3)=13.28, p=.004$, such that attempt episodes showed more complex language than ideation ($z=2.29, p=.022$) and positive mood ($z=2.94, p=.003$), but not more than depressed mood ($z=1.28, p=.202$) (Figure 6A). When examining “certain” episodes only, there

was a significant effect of episode type on clout or high-status language, $\chi^2(3)=11.10, p=.011$, such that attempt episodes showed more higher-status language than ideation ($z=2.41, p=.016$) but not depressed mood ($z=0.51, p=.061$) or positive mood ($z=0.36, p=.718$) episodes (Figure 6B). No significant effects by episode type emerged for other cognitive performance variables.

In terms of the various model variants that were run, as noted above, several significant effects of episode type were present when looking across all episodes but absent when looking at only episodes participants rated as being “very certain” about the dates, and vice versa. In general, the vast majority of significant effects found in those cases did not hold for other model variants. Specifically, very few effects emerged when looking only at the subset of attempts that included an enacted or initiated attempt (as opposed to aborted or interrupted attempt), when examining text messages only between individuals that participants indicated as being particularly close, or when shortening the time window of suicide attempts (from 14 to 7 days). For the few cases in which model variants were significant, each of the models showed a similar pattern of results in terms of differences between episode types and none boosted effect sizes of the observed episode type differences.

Taken together, these results suggest that suicide attempts appear to be associated with greater use of language indicating anxiety, sadness, and future orientation, as well as a more complex and higher status style of language. However, none of the effects by episode type indicated language differences that were unique to suicide attempts (e.g., attempts were higher in future orientation language compared to ideation and depressed mood, but not compared to positive mood). In fact, many of the observed significant pairwise comparisons were between attempt and ideation and not between attempt and non-suicidal episode types (depressed and positive mood). In some cases, effects were stronger when restricting analyses to only those

episodes for which participants were “very certain” of the dates. Analysis of episode type differences with other variant models, using different subsets of data, did not replicate or, in the case of significant effects, increase effect sizes.

Results of Primary Analysis 2: Does Language Approaching a Suicide Attempt Change Differently Over Time Relative to Language Changes During Other Episode Types?

When testing whether language use changed over the course of the two weeks leading up to a suicide attempt differently relative to change during the two weeks identified for other episode types, no significant interactions emerged for any of the variables related to social engagement (i.e., daily word/message counts for, and ratio between, outgoing and incoming messages). However, analyses revealed several significant episode type by time interactive effects for the other four constructs of interest. (See Table 5 and 7A-E for full results.)

Regarding *self-focus*, there was a significant interaction for singular first-person pronoun use, $\chi^2(3)=11.57, p=.009$, and pairwise comparisons revealed that the change over time approaching a suicide attempt significantly differed from change over time for ideation ($z=2.99, p=.003$) and depressed mood ($z=2.10, p=.035$), but not for positive mood ($z=0.89, p=.374$). As shown in Figure 7, self-focus tended to increase preceding an attempt, whereas depression and positive episodes were flatter and ideation appeared to show change over time in a downward direction.

Regarding *sentiment*, the use of words indicating positive emotion, anger, death, and emotional tone changed over time differently as a function of episode type. There was a significant interaction for positive emotion, $\chi^2(3)=41.67, p<.001$, such that positive emotion decreased more steeply during attempt episodes compared to all other episode types, including ideation ($z=1.96, p=.049$), depressed ($z=5.92, p<.001$), and positive ($z=3.50, p<.001$) episodes

(Figure 8A). There was also a significant interaction for anger words, such that anger increased more steeply during attempt compared to all other episode types, including ideation ($z=2.00$, $p=.046$), depressed ($z=2.49$, $p=.013$), and positive ($z=2.54$, $p=.0111$) episodes (Figure 8B). There was also a significant interaction for death words, $\chi^2(3)=9.47$, $p=.024$. However, there were no significant differences in change over time for attempt compared to all other episodes ($z_s=0.33-1.83$, $p_s=.067-.739$) (Figure 8C); ideation episodes appeared to show a steeper decrease in death words compared to both attempt and positive mood episodes. Lastly, there was a significant episode by time effect for emotional tone, $\chi^2(3)=26.81$, $p<.001$, such that attempt episodes decreased in the level of positive, upbeat language over time compared to depressed episodes ($t=4.27$, $p<.001$), but not compared to ideation ($t=1.48$, $p=.140$) or positive ($t=0.86$, $p=.390$) episodes (Figure 8D).

Changes in use of words associated with *time orientation* towards the present moment or the past were not different across episode types, but there was a significant time by episode type interactive effect for future-oriented words, $\chi^2(3)=13.46$, $p=.004$, such that future orientation increased more steeply during attempt episodes compared to positive episodes ($z=3.37$, $p<.001$), but attempt episodes were not significantly different from ideation ($z=0.88$, $p=.377$) or depressed ($z=1.65$, $p=.010$) episodes (Figure 9).

Regarding *cognitive performance*, There was a significant time by episode type interactive effect for the number of words used per sentence, $\chi^2(3)=8.27$, $p<.041$, such that participants used increasingly more words per sentence over time during attempt episodes compared to positive episodes ($t=4.05$, $p=.027$), though the comparison did not reach statistical significance when attempts were compared to positive ($t=2.89$, $p=.063$) episodes, and the pattern

over time for attempt and ideation episodes was not significantly different ($t=0.18, p=.869$) (Figure 10).

Finally, a series of tests were run to *check the robustness of the results*. When the same analyses were run but using a quadratic term, in the place of a linear term, for time in the episode type by time interactions, the results did not change substantively. In general, results when using variant models (i.e., subsetting the data to include only episodes with “certain” dates, only communication with close contacts, or only enacted suicide attempts) followed a similar pattern to findings from Analysis 1. That is, the majority of significant interactive effects emerged when examining all episodes or only “certain” episodes, but did not hold for the other model variants (e.g., only close contacts, only enacted attempts). However, for two variables – positive emotion and future orientation – observed significant interactive effects held across all model variants, perhaps indicating a more robust “signal” for each construct. (See Table 5 for a summary of variant tests.)

Taken together, the results suggest that communication may change in different ways during the time leading up to a suicide attempt compared to other times of lesser suicide risk. Unique to attempts, positive emotion decreased and anger increased to a greater extent as one approached a suicide attempt, relative to the other episode types. In addition, a number of other features of language appeared to change over time differently for attempts compared to other episode types (i.e., increased self-focus, future orientation, and elaborated fluency). However, the pattern of differences was generally mixed and did not uniquely distinguish attempts, or suicidal thoughts/behaviors (i.e., attempts and ideation) from other episodes. Analysis of interactive effects of episode type and time with other variant models did not change the pattern of results in substantive ways, though the replication of results for positive emotion across all models

suggests this may be a robust effect. Contrary to theoretical expectation, a number of non-attempt episodes appeared to show changes in language use over time, which may reflect noise in the data.

Discussion

In this pilot study, we examined personal electronic communication from past suicide attempters as a potential source of real-time markers of heightened suicide risk. We employed a within-subjects design to evaluate how language use in text messages differed and changed over time just before a suicide attempt (high risk), relative to other periods when participants had suicidal thoughts but did not attempt (moderate risk), or were depressed but not suicidal, or during periods of positive mood (low/minimal risk). We used an automated language analysis software package (LIWC) to produce scores on a set of variables intended to capture five psychological constructs of interest – self-focus, sentiment, social engagement, time-orientation, and cognitive performance – and then tested both for overall mean differences in language use and for differences in changes over time during the two weeks prior to a suicide attempt relative to during other episode types.

In terms of overall mean differences, results indicated that the period of high risk just before a suicide attempt was associated with messages indicating greater anxiety and sadness, as well as more complex and future-oriented language. However, none of these differences in language use were uniquely associated with suicide attempt episodes and therefore specific characteristics of a high suicide risk state. Although language use was different between attempt and ideation episodes on a number of language features, such as sadness and complexity, these differences did not hold when comparing attempts to other non-suicidal episodes. Therefore,

these analyses were unable to identify language features in text messages that could reliably identify high or moderate suicide risk states.

In terms of differences in patterns over time, results suggested that communication *changed* in different ways during the time leading up to a suicide attempt compared to other periods of lesser risk. Unique to attempts, anger increased and positive emotion decreased to a greater extent during the two weeks prior to suicide attempts, relative to the other episode types. Language indicating self-focus, future orientation, and the use of more elaborated fluency (i.e., more words per sentence) tended to increase over time during attempt episodes, though the trajectories for these variables could not reliably differentiate high suicide risk from other risk states. Overall, these results indicate that a small set of specific private text communication habits, particularly tied to use of emotional language, potentially provide clues into the suicidal mind and may serve as temporally sensitive markers of suicide risk.

Electronic Communication Patterns as Novel Markers of Risk

Self-focus. Operationalized by singular first-person pronoun use (“I” words), we hypothesized that self-focus would be greater during suicide attempt episodes relative to other episodes. This hypothesis was based on a theory construing suicide as a means to escape from negative self-focus (Baumeister, 1990) and the vicious feedback loop created from increasing self-focus and recognition of self-failures, as well as previous research demonstrating more self-focused communication among suicidal individuals (Stirman & Pennebaker, 2001; Venek et al., 2014). Results indicate that self-focus was not especially pronounced for attempt episodes when considering the entire two-week episode but self-focus appeared to increase *during* those two weeks. However, this increase was only steeper relative to ideation and depressed mood, not relative to positive mood.

This result ran contrary to our hypothesis and the general premise that degree of self-focus (or any other language variables for that matter) would be expected to map onto risk levels (i.e., no, low, moderate, high) in a linear manner. However, prior research suggests a possible reason why a language variable such as self-focus may behave similarly for attempt and positive episodes despite them being on opposite ends of the risk scale. Agitation and anxiety are better predictors of suicide attempt than a clinical diagnosis of depression (Busch et al., 2003; Nock, Hwang, et al., 2010), which is in line with the thinking that a suicide attempt, in contrast to suicide ideation or depression, is a behavior that requires energy and activation to enact. Accordingly, it is plausible that there are similarities between psychological states during attempt and during positive episodes, which may be reflected by similarities in language use. This result potentially suggests that self-focus may be especially sensitive to changes in risk related to increased energy or activation, and the “signal” may only be detectable by examining subtle temporal changes. Even so, this interpretation is based on speculation and change in self-focus over time did not differentiate high risk from other lower risk states, reflecting limits to its current utility as a means to identify individuals at risk of suicide attempt.

Sentiment. The current study hypothesized that text message communication prior to suicide attempts (relative to other time periods) would exhibit more negative sentiment (higher negative emotion and lower positive emotion) given prior research identifying a number of affective and emotional factors associated with suicide risk. One question we had was whether language reflecting negative affect (or lack of positive affect), which is a common feature of many psychological disorders (Brown, Chorpita, & Barlow, 1998), could be used to make fine-grained distinctions between levels of suicide risk. Interestingly, although suicide attempts were generally associated with higher levels of sadness and anxiety (but with significant overlap with

other episodes), suicide attempts were uniquely associated with *changes over time* in both positive emotion and anger. Specifically, decreases over time in positive emotion and increases over time in anger were markedly steeper leading up to a suicide attempt compared to other episodes.

A difference between episode types in anger is not entirely surprising given prior research has found an association between trait anger and suicide attempts (Ammerman, Kleiman, Uyeji, Knorr, & McCloskey, 2015; Daniel, Goldston, Erkanli, Franklin, & Mayfield, 2009; Hawkins & Cogle, 2013) and, as previously discussed, the fact that suicide attempts may require an increase in activation to enact. However, the fact that such a difference emerges only when looking at language use over time (i.e., leading up to a suicide attempt) underscores the potential importance and utility of examining risk factors for suicide attempts dynamically. Similarly, it was somewhat unexpected that differences between suicide attempt and other episodes for lower positive emotion emerged only when examining change over time, given one might expect a more persistent lack of positive emotion in language during the two weeks prior to a suicide attempt. These findings raise the intriguing possibility that psychological constructs like sentiment, which do not seem especially specific to suicide, may serve as unique indicators of high suicide risk when examined over time in high-risk populations.

Interestingly, use of death-related words did not significantly differ between episodes, suggesting the need to identify hidden and more subtle signs of risk beyond explicit endorsements of suicide-specific language. Given this was a small pilot study, more research is necessary but these findings underscore the utility of identifying risk markers using real-time data and raise the possibility that specific, temporally sensitive markers of suicide risk may be found in seemingly general, trait-like psychological constructs, such as sentiment and emotion.

Social engagement. The interpersonal theory of suicide (Joiner, 2005; Van Orden et al., 2010) proposes that the motivation behind suicide is driven by feelings of thwarted belongingness and perceived burdensomeness. In theory, social support should combat such feelings (of thwarted belongingness and perceived burdensomeness) and increase feelings of connectedness. We hypothesized that suicide attempt episodes would demonstrate greater signs of social disengagement. Results did not support this hypothesis. Differences in counts of and ratios between sent and received text messages between attempts and other episodes did not emerge, whether looking at episodes overall or over time.

Although these data do not provide evidence that communication habits, separate from language content, may be useful indicators of suicide risk, it is possible that these particular methods for capturing social engagement were too basic to detect any meaningful signal. For example, we only examined aggregate information about incoming and outgoing messages and were not able to examine more fine-grained details about these interactions, such as who was initiating conversations, whether certain texts to participants were going unanswered, or whether the content of texts may have indicated signs of social distress or rejection. Future studies on these or other data could examine more intricate interpersonal dynamics to better understand whether other social factors may help identify signs of heightened suicide risk.

Time orientation. We hypothesized that communication before a suicide attempt would demonstrate greater present-oriented language (e.g., “now,” “today”) and/or less past- or future-oriented language (e.g., “did,” “will”). This hypothesis was based on several theories of suicide. Baumeister (1990) argues that suicidal thinking involves the constriction of one’s psychological perspective, including the narrowing of time perspective to the present moment. Similarly, Shneidmann (1993) posits that suicide is not a disorder so much as a “transient psychological

constriction of affect and intellect... a tunneling or focusing or narrowing of the range of options usually available to that individual's consciousness..." (p. 24). Inconsistent with these theories, participants in this study did not use more present-oriented or fewer past-oriented words during suicidal episodes compared to non-suicidal episodes, and there were no significant differences in such language over time.

There were several significant effects when examining future-oriented language in general and over time, but the findings were mixed and did not consistently distinguish suicide attempts from other episodes. Curiously, future orientation was *higher* for attempts compared to ideation and depressed mood but not positive mood, and future orientation increased more steeply for positive mood compared to attempts but not ideation or depressed mood. Similar to the finding for self-focus, it is possible that high risk and minimal/no risk states share similar psychological features due to the assumption that both are "activated" cognitive states. However, based on the theory that the suicidal state involves a sort of cognitive constriction to the here and now, it is difficult to understand why a high-risk state would be characterized by more, rather than less, orientation towards the future. It is possible that the psychological construct of time orientation is too complex to be captured through single-word analyses.

Cognitive performance. Based on the notion of cognitive narrowing discussed previously and the idea that the suicidal state may entail an increased focus on concrete sensations compared to abstract ideas, we hypothesized that participants would show decreased cognitive performance prior to suicide attempts, operationalized by complexity, sophistication, and increased fluency of language. Results across a number of variables were mixed and did not clearly indicate that cognitive performance variables uniquely differentiated suicide attempt from other episodes. Language during suicide attempt episodes was actually more complex and

sophisticated relative to several other episode types. Attempt episodes generally showed a steeper increase in fluency (number of words per sentence) over time compared to non-suicidal episodes, but not compared to ideation, indicating that elaborated fluency may be a useful marker for suicide risk, even if not unique to suicide attempt. Again, however, results for cognitive performance variables examined were mixed. Similar to time orientation, it is possible that capturing cognitive performance (or, more specifically, cognitive rigidity or narrowing) may require more complex approaches than was afforded using LIWC software. Future studies could use qualitative coding to operationalize this construct in more sophisticated ways.

Consistency of Results across Analyses

Given the lack of prior research in this area, our empirical questions included: a) whether high suicide risk ‘signals’ in communication were present, and if so, b) whether they would be stronger or weaker depending on the particular dataset used in the analyses. In general, the pattern of results did not change dramatically when using subsets of the data, though there were a few notable observations. To address possible internal validity concerns, analyses were rerun including only episodes participants rated as being “very certain” about the dates. In a number of cases, significant effects of episode type were present when examining all episodes but absent when examining only “certain” episodes, or vice versa. In other cases, significant effects for all episodes held when examining only “certain” episodes, especially for slope analyses. Given these results, it may be that differences in some features of communication were strong enough to emerge even if dates that participants selected may not have been exactly accurate, especially when examining change over time; it also may have helped that a fairly large window of time (i.e., two weeks) was captured for each episode.

To address external validity and boundary considerations, analyses were rerun using only text messages between individuals with which participants indicated having a close relationship. In general, this did not either increase effect sizes or produce new significant effects. In other words, results of analyses examining differences between episode types were stronger when looking at all text messages versus only the close relationships subset. This raises the possibility that communication style during high-risk states may be ubiquitous and not dependent on closeness to the recipient. We also ran additional analyses to determine sensitivity of results to the time window of the suicide attempt episode. The study was designed to consider the full two weeks prior to the attempt as the “attempt episode” because of recent research showing that planning and preparation typically occur within a few days of the eventual attempt and most, if not all, within a week or two of the attempt (Millner et al., 2016). Visual analyses suggested it was also worth examining results using a one-week time window, but narrowing the window of attempt generally did not produce larger effect sizes, and it is very possible that the critical temporal fluctuations differ across variables. For example, it may be that variables related to anxiety and agitation, which have been shown to closely precipitate attempts (Busch et al., 2003), have a narrower time window of detection than variables related to amount of communication, though these analyses did not bear out this hypothesis. An additional set of analyses using only texts tied to enacted or “actual” attempts (vs. aborted or otherwise not enacted attempts) did not significantly increase effect sizes, which is somewhat unexpected if operating under the premise that “high-risk” language use would be especially pronounced for suicidal behaviors enacted with greater intent and seriousness. However, the number of enacted attempts was so small (6 out of 21 total attempt episodes) that these null findings should be

interpreted with caution. Notwithstanding, this is an important question for future research given enacted episodes present the greatest threat to the individual.

Finally, results for additional analyses varying which groups were compared were mixed. It was generally difficult to find distinctions between suicidal versus non-suicidal episodes, and when testing for these differences, no significant effects emerged that were not already present when comparing episode types individually. This suggests that perhaps language differences do not break down along these lines (e.g., ideation and depressed episode may look similar to one another, perhaps because they both involve negative mood). Comparing messages during attempt episodes to all other messages produced several significant results, though not conceptually different from prior results using all four episode types, further underscoring the possibility of using communication markers to uniquely distinguish suicide attempts from other periods of lower suicide risk.

Taken together, results of the analyses subsetting the data in different ways suggest that language differences, when significant, generally emerged when examining all episodes or only “certain” episodes but not for other variant analyses. These results may indicate that the primary analyses are fairly robust and remain even amidst possible noise introduced by issues with internal and external validity. These findings also offer the practical benefit of tracking suicide risk through language without the need to process or filter the data in particular ways. However, it should be noted that we cannot rule out the possibility that the null findings among many of the variant analyses are actually the “true” results and that the significant effects observed among the primary analyses are in fact artifacts.

Framework for Understanding Markers of High-Risk States

Recent calls have been made to better understand factors differentiating suicide attempters and completions from suicide ideators (e.g., Klonsky & May, 2014) and to improve our ability to make short-term predictions of suicidal behaviors (e.g., Glenn & Nock, 2014). Given the relatively high prevalence of suicidal thoughts compared to action (i.e., attempts and completions), the first distinction is important to make sure suicide prevention efforts reach those at greatest risk, and this study sheds light on possible fine-grained distinctions in language among suicide attempters. Given the strong research base on general protective and risk factors of suicide but paucity of evidence identifying acute, proximal risk factors of suicide, the second distinction is critical to having tools to accurately assess where someone is on the pathway towards attempting suicide. Combining these calls to action, this study sought to differentiate suicide attempt (high risk) and suicide ideation (moderate risk) *within the same person*. The fact that there were some features specific to attempts is promising and indicates there may be ways to make such distinctions.

To aid conceptual understanding of markers or risk factors of suicide in this study (and others), it may be useful to explicate a taxonomy of possible relationships between communication-related markers and suicide outcomes. Borrowing terminology from Kraemer et al. (1997), we could think of a communication habit that differs between individuals who vary by general or “trait” level of suicide risk but that does not change over time as a *fixed* marker of risk. In contrast, a communication habit that is associated with suicide risk and can change over time could be considered a *variable* marker of risk. It is important to note that this study, by virtue of its within-subjects design, focused solely on identifying potential variable markers that characterize a high-risk state. Therefore, just because a given construct or variable (e.g.,

language complexity) did not yield significant results in this study does not mean that the construct is unimportant; it is possible that language indicating orientation to the present moment distinguishes *between* individuals at different levels of risk but is fairly stable and does not change *within* a given high-risk individual.

There are multiple ways to think about the potential language markers of suicide risk found in this study in terms of their temporal scales and psychological specificity. Factors that differed by episode type overall but not as a function of time (e.g., anxiety and language complexity showed mean differences across episode types but not slope differences) could be thought of as variable markers with larger temporal scales or windows compared to factors that did not differ by episode type overall but differed in their relative trajectories (e.g., self-focus and positive emotion). Such distinctions are very important to building models to monitor and isolate periods of high risk. Likewise, it is important to better understand a factor's specificity in terms of the psychological vulnerability it might reflect. Certain language variables may uniquely distinguish high suicide risk from moderate or lower levels of risk, such as differences in change over time in sentiment. Other language variables may be sensitive to suicide risk but not be able to differentiate specific levels of risk (i.e., differentiate between attempt and ideation), or may be sensitive to negative mood but not suicidality specifically (i.e., differentiate between attempt/ideation and depression), though this study did not find language variables that were able to cleanly make these particular distinctions. This framework for thinking about markers of risk may be helpful to better understand phenomena whose temporal and psychological dynamics are not yet established.

Future Directions in Textual Analyses to Enhance Suicide Prediction

There are a number of exciting questions to pursue, both with this current dataset and with new datasets. Although multiple forms of electronic communication were collected, this study focused only on text messages, largely because of the number of messages. A recent study surveying smartphone users showed that text messaging was the most widely and frequently used feature, with 97% of phone users using this feature (Smith, 2015). SMS was also an appealing medium given its status as a private means of communication, which may make it more likely for individuals to share thoughts and feelings openly. Extending beyond SMS, it would be possible to examine other data sources popular among our sample. Web search history, email (i.e., Gmail), and Twitter were used inconsistently by participants, but Facebook messages (sent privately, in contrast to public posts) were more ubiquitous so provide a promising avenue for additional analyses. Given anecdotal evidence that participants used Facebook messages in similar ways to SMS, it would be interesting to use these Facebook data as a quasi-replication study.

There are also additional ways to analyze the SMS data by developing new sets of predictors in our models. In this pilot study, we limited our linguistic analyses to a handful of categories based on the presence of single words in a custom dictionary (LIWC). One weakness of this approach is that examining single words in isolation can fail to capture the semantic context of the word (e.g., “not happy” would count as “positive emotion” because negation is not accounted for) and has not been modified based on language categories tailored towards constructs of interest for suicide specifically. Future studies could examine 2- or 3-word phrases (called n-grams) to capture more semantic meaning and create additional custom dictionaries. Even more, it may be possible to take a qualitative coding approach whereby researchers could

develop a codebook of themes (e.g., relationship distress, hopelessness) and raters could then blindly code episodes to see whether episodes differ thematically. Furthermore, data-driven methods for understanding attempt episodes include unsupervised learning techniques, such as topic modeling, to identify themes in communication prior to suicide attempts that might provide richer descriptions of the themes and inform future predictors of interest. (See Kern et al., 2016 for a useful review of methods for analyzing social media language.)

The results of the current study could also serve as the basis for building a machine learning model to better identify the family of text features associated with suicide risk. Machine or classification learning refers to a set of computing methods designed to predict membership to a class based on a set of features (James, Witten, Hastie, & Tibshirani, 2013). Machine learning is often mentioned with the term ‘big data’ as a means to predict outcomes based on large quantities of data points. For example, machine learning is used by search engines to provide suggestions of the most probable search terms based on the initial input or by email services to identify spam and categorize messages (Aberdeen, Pacovsky, & Slater, 2010). ‘Learning’ occurs through the iterative process of training a classifier based on a set of training data and then testing the performance of the classifier on a set of test data (James et al., 2013).

Clinical scientists have been slow thus far to harness machine learning techniques, which may be particularly useful for predicting low base rate behaviors like suicide attempts, but such approaches have been gaining traction in recent years. In a study of Army soldiers, Kessler and colleagues (2015) created a machine learning classifier based on known risk factors and found that 5% of individuals assigned by the classifier to the highest risk category comprised over 50% of suicide deaths at follow-up. The strong accuracy achieved in this study demonstrates the

ability to use an ensemble of predictors, which on their own would carry trivial predictive value, to predict a complex multifactorial clinical outcome.

The current results could guide development of a machine learning model to predict and classify episode types by identifying text features associated with suicide risk, which our research group has already begun to explore. In the current study, we restricted analyses to only communication variables for which we had theoretical interest. An advantage of having such a rich dataset (text messages) is it provides a large set of potential features to be included in a machine learning classifier, including many for which we would not otherwise have theoretical reason to include *a priori*. Such richness offers the opportunity to see whether a data-driven approach can detect signals that are statistically related to suicide, but which are not known theoretically and that we as humans would otherwise not detect. In a recently published study, our group used a deep neural net machine learning classifier to model within-subject episode type differences between attempt/ideation episodes and depressed mood episodes using an atheoretical set of communication variables, including ones not analyzed in this current study (Nobles, Glenn, Kowsari, Teachman, & Barnes, 2018). Sensitivity and specificity were moderate to strong, indicating that the algorithm performed fairly well at classifying episodes. These findings suggest the promise of detecting “hidden” but meaningful signals using predictive models, even when only a small number of classification units are available. Using this machine learning framework, future studies could track people in real time (vs. retrospectively) to determine sensitivity and specificity of suicide risk predictions.

Clinical Implications

Despite decades of research, judgments of imminent suicide risk remain poor in part due to a reliance on at-risk individuals’ subjective self-report, which is prone to efforts to conceal

and/or an inability to accurately assess one's current state. Knowledge gained from this study could put us one step closer to the development of an *objective* monitoring tool capable of tracking individuals' communication "behind the scenes," notifying suicidal individuals and/or their clinician or family if their patterns of communication indicate increasing levels of suicide risk. To further increase precision, it may even be possible to someday develop a machine learning algorithm to 'learn' how a given individual differs in general from a normalized sample to increase and individualize predictive accuracy. This kind of approach that is temporally sensitive and takes into account individual differences could have profound implications for predicting *when* a person, not just *who*, is at risk of suicide attempt. Behavioral tools like these have the potential to significantly reduce the rates and public health burden of suicide.

Although the possible future clinical applications of this work could help address a major public health burden, the development of a predictive tool would raise a number of important ethical challenges. Such considerations include determining how the consent or permission process for users would work, who would get notified if text messages included elevated risk, and what intervention would be undertaken. Similar to diagnostic medical tests that produce certain levels of false positives and false negatives, decisions would need to be made regarding the most appropriate threshold for what would be considered "elevated risk" deserving of intervention. For example, is it preferable to flag more individuals but with less certainty of risk (producing more false positives) or fewer individuals but with greater certainty of risk (producing more false negatives)? The field would also need to grapple with questions related to mandated reporting and involuntary hospitalization. For example, what is the most appropriate action for someone who denies having suicidal thoughts, plans, or intent but whose text messages indicate elevated risk? Would such a situation warrant hospitalization? These and

many more ethical questions will need to be addressed if a predictive monitoring tool for suicide risk is to be effectively implemented.

Limitations and Conclusion

There are several methodological limitations to acknowledge. First, dates and information regarding episodes relied on retrospective self-report, which may not have been entirely reliable, especially for less recent episodes. A prospective design in which participants were assessed frequently for the presence of suicidal thoughts or behaviors would resolve some concerns about self-report. However, such a design was not practical given the very low base rate of suicide attempts and would necessitate more participants than is feasible for a laboratory study. Further, concerns about this retrospective report are somewhat minimized because, while suicide history was reported retrospectively, the actual communication data used for analyses were not and thus are ecologically valid and not prone to demand characteristics.

Second, classification of episode type depended on participants' interpretations of whether their behaviors qualified as a specific type of event. Prior research has shown that single-item self-report questions can lead to misclassification (Millner et al., 2015). To overcome this potential limitation, efforts were made to ensure the language used was precise, and multiple follow-up questions were asked to assess suicidality of each episode beyond a yes/no question (e.g., asking for suicide ideation severity using a continuous scale). However, future studies could use more strictly objective measures, such as clinical charts, to categorize events (though two suicide attempts with the same level of medical severity or lethality do not necessarily entail the same extent of planning, intent, and desire to die associated with the act).

Third, on the one hand, a strength of this study design is its emphasis on differentiating suicide attempts from ideation given we are ultimately concerned with preventing suicidal

behaviors, not just thoughts. However, logistics of accessing and downloading communication data necessitated enrolling participants with non-lethal attempts. It is possible that characteristics of suicide attempters differ from those of suicide *completers*, which has been borne out somewhat by prior research (e.g., DeJong, Overholser, & Stockmeier, 2010; Joiner Jr, Pettit, Walker, & Voelz, 2002). For example, suicide completers demonstrate higher levels of perceived burdensomeness and are more likely to have experienced job and financial stress and used alcohol or drugs prior to their attempt. Further, while rates of attempt are greater for females, males are about four times more likely to die by suicide (Murphy, Xu, & Kochanek, 2013). Psychological autopsy studies examining communications by individuals who died by suicide could inform this question. Relatedly, we used a broad definition of what we considered a “suicide attempt episode,” including not only attempts in which some concrete action was initiated (e.g., at least one pill swallowed) but also interrupted or aborted attempts (e.g., traveled to and strongly considered jumping from a height). This approach may have changed or decreased the size of observed effects.

Fourth, despite a relatively long recruitment window, the number of participants and reported episodes in the study were small, providing only enough power to detect large effect sizes. (This small sample was primarily a function of recruiting for low base rate behaviors among a high-functioning population, but also due to limitations in how long ago text messaging data could be collected.) In addition, the random effects structure of the mixed effects models was elaborate (appropriately so to maximize generalizability of the results), which plausibly resulted in further loss of power. Therefore, there is the increased possibility of Type II error. Even so, it is important to consider the tradeoffs associated with various research designs.

The current study utilized a novel, within-subject, laboratory-based research design to identify and better understand real-time patterns in communication unique to periods preceding suicide attempts. This is the first research study, to our knowledge, to examine the association between private text messaging data and mental health outcomes, suicide or otherwise. This pilot investigation identified novel predictors of suicidal behaviors, which may be utilized in the future by machine learning models to *predict* acute suicide risk and identify whether and where an individual is on the pathway from thinking about suicide to acting on those thoughts. It is our hope that this research puts us one step closer to developing more objective, effective ways to predict and prevent future suicide-related behaviors.

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Table 1. Participant characteristics

Variable	<i>N</i> =33
Mean (<i>SD</i>) age in years	20.4 (2.4)
Sex (% female)	84.8
Citizenship (%)	
U.S.	97.0
Non-U.S.	3.0
Ethnicity (%)	
Non-Hispanic	87.9
Hispanic	12.1
Race (%)	
Caucasian	60.6
Asian	18.2
African American	9.1
Multiracial	6.1
Other	3.0
Education (%)	
Graduate degree	3.0
Bachelor's degree	3.0
Some college	94.0
Lifetime self-harm presence (%)	
Nonsuicidal self-injury (NSSI)	48.4
Suicide ideation	90.9
Actual (enacted) suicide attempt	81.8
Interrupted/aborted suicide attempt	78.8
Lifetime self-harm – mean # (<i>SD</i>)	
Actual (enacted) suicide attempt	1.43 (0.81)
Interrupted suicide attempt	1.62 (0.87)
Aborted suicide attempt	1.95 (2.06)
Mental health problem lifetime presence (%)	
Yes	84.8
No	9.1
Prefer not to answer	6.1
Diagnoses lifetime presence (%)	

Mood disorder	48.5
Anxiety disorder	39.4
Substance use disorder	3.0
Any disorder	57.6
Close contacts – mean # (<i>SD</i>)	8.24 (1.79)
Iatrogenic – change pre to post	
Mood (0-10)	-0.20
Desire to die (0-10)	0.20

Table 2. Episode characteristics

Variable	Suicide Attempt	Suicide Ideation	Depressed Mood	Positive Mood
Total episodes reported	66	68	78	81
Mean episodes reported per participant (<i>SD</i>)	1.97 (0.95)	2.06 (0.90)	2.36 (0.82)	2.45 (0.71)
Total episodes with SMS data	21	32	40	41
Total # of different participants	15	20	22	24
Mean episodes with SMS data (<i>SD</i>)	1.40 (0.74)	1.60 (0.75)	1.81 (0.89)	1.70 (0.69)
Messages per episode (<i>SD</i>)	1197.14 (1359.41)	1298.13 (1089.01)	1639.78 (2015.81)	1395.29 (1755.34)
Messages per day (<i>SD</i>)	89.8 (117.1)	101.3 (110.5)	124.7 (166.9)	100.4 (142.5)
Outgoing messages (%)	47.6	46.3	42.7	44.1
Certainty (%)				
Very certain (exact day)	47.6	53.1	60.0	70.7
Somewhat certain (off by few days)	38.1	25.0	37.5	24.4
Not very certain (off by a week)	9.5	21.9	0	4.9
Not at all (off by two weeks or more)	4.8	0.0	2.5	0.0
Close relationships (%) ^a				
Family (e.g., parent, sibling)	6.3	11.7	6.8	7.2
Friends (e.g., best friend, close friend)	31.5	39.7	42.1	26.5
Significant other (e.g., spouse, partner)	18.9	12.4	14.6	24.5
None	43.4	36.2	36.5	41.7
Mean days since episode (<i>SD</i>)	313.0 (270.6)	260.9 (272.4)	239.5 (236.6)	230.3 (218.0)
Suicide ideation – active ^b				
Presence (%)	90.5	73.9	5.9	–
Severity at worst point (0-5) (<i>SD</i>)	4.05 (1.02)	3.18 (0.86)	0.18 (0.72)	–

Severity on average (0-5) (<i>SD</i>)	2.86 (0.91)	2.25 (0.70)	0.12 (0.54)	–
Depressive/anxiety symptoms ^c				
Depression presence (%)	90.5	89.3	67.6	0.0
Depression severity (1-4) (<i>SD</i>)	3.48 (0.89)	3.27 (0.80)	3.00 (0.92)	1.19 (0.32)
Anxiety severity (1-4) (<i>SD</i>)	3.36 (0.62)	3.39 (0.82)	2.88 (1.05)	1.68 (0.77)
Negative mood (1-5) (<i>SD</i>)	3.70 (0.71)	3.39 (0.55)	3.30 (0.70)	1.62 (0.54)

^a Participants provided the names and type of relationship for 5-10 individuals with whom they communicated most frequently and/or were particularly close.

^b Items adapted from the Self-Injurious Thoughts and Behaviors Interview (SITBI) and the Columbia-Suicide Severity Rating Scale (C-SSRS); questions refer to the presence and intensity of active thoughts of wanting to kill oneself.

^c Items adapted from the Beck Depression Inventory-II (BDI-II) and the Patient Health Questionnaire-4 (PHQ-4); depression questions refer to feeling depressed, empty, hopeless, and/or losing interest in usual activities, and anxiety questions refer to feeling nervous and/or not being able to stop worrying.

Note. SMS = Short Messaging Service

Table 3. Characteristics of reported suicide attempts with available text messaging data

Variable	Attempt (<i>n</i> =21)
Self-reported method (#) ^a	
Medications/alcohol	9
Hanging/suffocation	8
Jump from height	5
Crashing/stepping in front of car	3
Knife/sharp object	2
Firearm	1
Status of attempt	
Enacted (some action taken)	6
Interrupted/aborted (no action taken)	15
Intent (1-5) (<i>SD</i>)	3.95 (0.86)
Lethality – subjective (1-5) (<i>SD</i>)	3.38 (0.86)
Plan made (%)	
Less than 1 hour prior	33.3
1 hour – 1 day prior	19.0
1 – 2 days prior	19.0
3 days – 2 weeks	19.1
Not sure	9.5
Circumstance contributing most to attempt (#)	
Academic/job stress	6
Problems with sig other/friend	6
Health/psychiatric problems	2
Loneliness	2
Death of someone else	1
Humiliating event	1
Other	2
Professional treatment received within two weeks (%) ^b	
Prior to attempt	42.9
After attempt	47.6

^a Participants were able to endorse multiple suicide methods

^b Medical and/or psychiatric treatment (i.e., psychiatrist, general practitioner, psychologist, or licensed mental health practitioner)

Table 4. Psychological constructs and corresponding linguistic features examined in the study

Psychological construct	Linguistic construct	Specific features (LIWC codes, if applicable)
1. Self-focus	First-person pronoun usage	1 st person singular (<i>i</i>) 1 st person plural (<i>we</i>)
2. Sentiment and suicidal content	Emotion and death words	Positive emotion (<i>posemo</i>) Negative emotion (<i>negemo</i>) Anger (<i>anger</i>) Anxiety (<i>anx</i>) Sadness (<i>sad</i>) Death (<i>death</i>) Emotional tone (<i>Tone</i>)
3. Social engagement	Communication pattern in metadata	Ratio of sent vs. received # words (<i>WC</i>) Ratio of sent vs. received # messages Frequency of sent messages Frequency of received messages
4. Time orientation	Time referential words	Present focus (<i>focuspresent</i>) Past focus (<i>focuspast</i>) Future focus (<i>focusfuture</i>)
5. Cognitive performance	Linguistic structure	Complexity of language (<i>Analytic</i>) Projected status of language (<i>Clout</i>) Words per sentence (<i>WPS</i>) Words greater than six letters (<i>Sixltr</i>)

Note. LIWC = Linguistic Inquiry and Word Count software

Table 6A. Analysis of deviance table and pairwise comparisons for fixed effect of episode type on self-focus variables

Self-Focus	Test	df	<i>p</i>	β	<i>SE</i>	Test	<i>p</i>
1st-person pronouns – singular (i)	$\chi^2=1.62$	3	.656				
1st-person pronouns – plural (we)	$\chi^2=0.28$	3	.964				

Note. Pairwise comparisons performed only for significant fixed effects

Table 6B. Analysis of deviance table and pairwise comparisons for fixed effect of episode type of sentiment

Sentiment	Test	df	<i>p</i>	β	<i>SE</i>	Test	<i>p</i>
Positive emotion (posemo)	$\chi^2=2.18$	3	.536				
Negative emotion (negemo)	$\chi^2=2.15$	3	.543				
Anxiety (anx)	$\chi^2=3.62$	3	.306				
Anger (anger)	$\chi^2=1.45$	3	.694				
Sadness (sad)	$\chi^2=8.74$	3	.033				
Intercept				-5.135	0.072	$z=-71.81$	<.001
Ideation vs. Attempt				-0.247	0.094	$z=-2.64$	.008
Depressed vs. Attempt				-0.113	0.104	$z=-1.09$	.277
Positive vs. Attempt				-0.097	0.091	$z=-1.07$	.285
Depressed vs. Ideation				0.134	0.078	$z=1.71$	.088
Positive vs. Ideation				0.149	0.069	$z=2.18$	.029
Positive vs. Depressed				0.016	0.073	$z=0.22$	.827
Death (death)	$\chi^2=1.79$	3	.671				
Emotional tone (Tone)	$\chi^2=1.36$	3	.716				

Note. Pairwise comparisons performed only for significant fixed effects

Table 6C. Analysis of deviance table and pairwise comparisons for fixed effect of episode type on social engagement variables

Social Engagement	Test	df	<i>p</i>	β	<i>SE</i>	Test	<i>p</i>
Ratio sent vs. received words	$\chi^2=2.41$	3	.493				
Ratio sent vs. received messages	$\chi^2=7.76$	3	.051				
# outgoing messages	$\chi^2=6.75$	3	.080				
# incoming messages	$\chi^2=4.89$	3	.180				

Note. Pairwise comparisons performed only for significant fixed effects

Table 6D. Analysis of deviance table and pairwise comparisons for fixed effect of episode type on time orientation variables

Time Orientation	Test	df	<i>p</i>	β	<i>SE</i>	Test	<i>p</i>
Present focus (focuspresent)	$\chi^2=2.48$	3	.479				
Past focus (focuspast)	$\chi^2=0.89$	3	.828				
Future focus (focusfuture)	$\chi^2=9.73$	3	.021				
Intercept				-3.512	0.045	$z=-78.83$	<.001
Ideation vs. Attempt				-0.107	0.047	$z=-2.30$	.021
Depressed vs. Attempt				-0.094	0.050	$z=-1.89$	.059
Positive vs. Attempt				-0.014	0.045	$z=-0.31$	.756
Depressed vs. Ideation				0.012	0.044	$z=0.29$	.771
Positive vs. Ideation				0.093	0.039	$z=2.36$	.019
Positive vs. Depressed				0.080	0.040	$z=2.02$	.044

Note. Pairwise comparisons performed only for significant fixed effects

Table 6E. Analysis of deviance table and pairwise comparisons for fixed effect of episode type on cognitive performance variables

Cognitive Performance	Test	df	<i>p</i>	β	<i>SE</i>	Test	<i>p</i>
Complexity (Analytic)	$\chi^2=13.28$	3	.004				
Intercept				40.53	1.627	$z=24.90$	<.001
Ideation vs. Attempt				-2.111	0.921	$z=-2.29$	.022
Depressed vs. Attempt				-1.493	1.170	$z=-1.28$	.202
Positive vs. Attempt				-2.631	0.895	$z=-2.94$	.003
Depressed vs. Ideation				0.618	0.833	$z=0.74$	.458
Positive vs. Ideation				-0.520	0.759	$z=-0.69$	.493
Positive vs. Depressed				-1.138	0.719	$z=-1.58$	.114
Status (Clout)	$\chi^2=6.21$	3	.102				
Words per sentence (WPS)	$\chi^2=0.60$	3	.896				
Words > Six letters (Sixltr)	$\chi^2=1.88$	3	.597				

Note. Pairwise comparisons performed only for significant fixed effects

Table 7A. Analysis of deviance and pairwise comparisons for fixed effects of episode type, time, and their interaction (with interaction results shaded in gray) for self-focus variables

Self-Focus	Test	df	<i>p</i>	β	<i>SE</i>	Test	<i>p</i>
1st-person pronouns – singular (i)							
Episode type	$\chi^2=1.98$	3	.577				
Time	$\chi^2=0.04$	1	.844				
Episode type \times Time	$\chi^2=11.57$	3	.009				
Episode type (Attempt vs. Ideation) \times Time				-0.015	0.005	$z=-2.99$	.003
Episode type (Attempt vs. Depressed) \times Time				-0.010	0.005	$z=-2.10$	.035
Episode type (Attempt vs. Positive) \times Time				-0.004	0.005	$z=-0.89$	.374
1st-person pronouns – plural (we)							
Episode type	$\chi^2=0.31$	3	.959				
Time	$\chi^2=1.12$	1	.290				
Episode type \times Time	$\chi^2=1.37$	3	.712				

Note. Pairwise comparisons performed only for significant interactions

Table 7B. Analysis of deviance and pairwise comparisons for fixed effects of episode type, time, and their interaction (with interaction results shaded in gray) for sentiment variables

Sentiment	Test	df	<i>p</i>	β	<i>SE</i>	Test	<i>p</i>
Positive emotion (posemo)							
Episode type	$\chi^2=2.35$	3	.503				
Time	$\chi^2=2.56$	1	.110				
Episode type \times Time	$\chi^2=41.67$	3	<.001				
Episode type (Attempt vs. Ideation) \times Time				0.010	0.005	$z=1.96$	.049
Episode type (Attempt vs. Depressed) \times Time				0.027	0.005	$z=5.92$	<.001
Episode type (Attempt vs. Positive) \times Time				0.016	0.005	$z=3.50$	<.001
Negative emotion (negemo)							
Episode type	$\chi^2=2.19$	3	.534				
Time	$\chi^2=7.12$	1	.008				
Episode type \times Time	$\chi^2=4.93$	3	.177				
Anxiety (anx)							
Episode type	$\chi^2=3.46$	3	.326				
Time	$\chi^2=2.97$	1	.085				
Episode type \times Time	$\chi^2=2.31$	3	.511				
Anger (anger)							
Episode type	$\chi^2=1.30$	3	.729				
Time	$\chi^2=2.58$	1	.108				
Episode type \times Time	$\chi^2=7.83$	3	.049				
Episode type (Attempt vs. Ideation) \times Time				-0.023	0.012	$z=-2.00$	.046
Episode type (Attempt vs. Depressed) \times Time				-0.026	0.011	$z=-2.49$	.013
Episode type (Attempt vs. Positive) \times Time				-0.027	0.011	$z=-2.54$	.011
Sadness (sad)							
Episode type	$\chi^2=8.99$	3	.029				
Time	$\chi^2=3.27$	1	.071				
Episode type \times Time	$\chi^2=1.33$	3	.721				
Death (death)							

Episode type	$\chi^2=1.70$	3	.637				
Time	$\chi^2=0.68$	1	.409				
Episode type \times Time	$\chi^2=9.47$	3	.024				
Episode type (Attempt vs. Ideation) \times Time				-0.049	0.027	$z=-1.83$	.067
Episode type (Attempt vs. Depressed) \times Time				-0.008	0.025	$z=-0.33$	.739
Episode type (Attempt vs. Positive) \times Time				-0.021	0.025	$z=-0.82$	.412
Emotional Tone (Tone)							
Episode type	$\chi^2=1.43$	3	.698				
Time	$\chi^2=4.51$	1	.034				
Episode type \times Time	$\chi^2=26.81$	3	<.001				
Episode type (Attempt vs. Ideation) \times Time				0.149	0.101	$t=1.48$	.140
Episode type (Attempt vs. Depressed) \times Time				0.401	0.094	$t=4.27$	<.001
Episode type (Attempt vs. Positive) \times Time				0.083	0.096	$t=0.86$	.390

Note. Pairwise comparisons performed only for significant interactions

Table 7C. Analysis of deviance and pairwise comparisons for fixed effects of episode type, time, and their interaction (with interaction results shaded in gray) for social engagement variables

Social Engagement	Test	df	<i>p</i>	β	<i>SE</i>	Test	<i>p</i>
Ratio sent vs. received # words							
Episode type	$\chi^2=2.36$	3	.501				
Time	$\chi^2=1.12$	1	.289				
Episode type \times Time	$\chi^2=4.99$	3	.172				
Ratio sent vs. received # messages							
Episode type	$\chi^2=6.75$	3	.080				
Time	$\chi^2=0.25$	1	.615				
Episode type \times Time	$\chi^2=1.70$	3	.636				
# outgoing messages							
Episode type	$\chi^2=6.88$	3	.076				
Time	$\chi^2=9.98$	1	.002				
Episode type \times Time	$\chi^2=4.22$	3	.238				
# incoming messages							
Episode type	$\chi^2=4.89$	3	.180				
Time	$\chi^2=9.95$	1	.001				
Episode type \times Time	$\chi^2=1.58$	3	.664				

Note. Pairwise comparisons performed only for significant interactions

Table 7D. Analysis of deviance and pairwise comparisons for fixed effects of episode type, time, and their interaction (with interaction results shaded in gray) for time orientation variables

Time Orientation	Test	df	<i>p</i>	β	<i>SE</i>	Test	<i>p</i>
Present focus (focuspresent)							
Episode type	$\chi^2=2.60$	3	.458				
Time	$\chi^2=17.59$	1	<.001				
Episode type \times Time	$\chi^2=0.97$	3	.810				
Past focus (focuspast)							
Episode type	$\chi^2=2.68$	3	.445				
Time	$\chi^2=1.36$	1	.244				
Episode type \times Time	$\chi^2=1.20$	3	.753				
Future focus (focusfuture)							
Episode type	$\chi^2=9.73$	3	.021				
Time	$\chi^2=0.02$	1	.894				
Episode type \times Time	$\chi^2=13.46$	3	.004				
Episode type (Attempt vs. Ideation) \times Time				0.005	0.006	<i>z</i> =0.88	.377
Episode type (Attempt vs. Depressed) \times Time				0.009	0.005	<i>z</i> =1.65	.010
Episode type (Attempt vs. Positive) \times Time				0.019	0.006	<i>z</i> =3.37	<.001

Note. Pairwise comparisons performed only for significant interactions

Table 7E. Analysis of deviance and pairwise comparisons for fixed effects of episode type, time, and their interaction (with interaction results shaded in gray) for cognitive performance variables

Cognitive Performance	Test	df	<i>p</i>	β	<i>SE</i>	Test	<i>p</i>
Complexity (Analytic)							
Episode type	$\chi^2=13.56$	3	.004				
Time	$\chi^2=7.99$	1	.005				
Episode type \times Time	$\chi^2=0.67$	3	.879				
Status (Clout)							
Episode type	$\chi^2=7.47$	3	.058				
Time	$\chi^2=0.15$	1	.699				
Episode type \times Time	$\chi^2=5.79$	3	.122				
Words per sentence (WPS)							
Episode type	$\chi^2=0.58$	3	.902				
Time	$\chi^2=0.19$	1	.666				
Episode type \times Time	$\chi^2=31.92$	3	<.001				
Episode type (Attempt vs. Ideation) \times Time				0.003	0.016	<i>t</i> =0.18	.869
Episode type (Attempt vs. Depressed) \times Time				-0.042	0.015	<i>t</i> =-2.89	.063
Episode type (Attempt vs. Positive) \times Time				-0.060	0.015	<i>t</i> =-4.05	.027
Words > Six letters (Sixltr)							
Episode type	$\chi^2=0.58$	3	.902				
Time	$\chi^2=0.19$	1	.666				
Episode type \times Time	$\chi^2=32.18$	3	<.001				

Note. Pairwise comparisons performed only for significant interactions

Figure 1. Recruitment CONSORT diagram

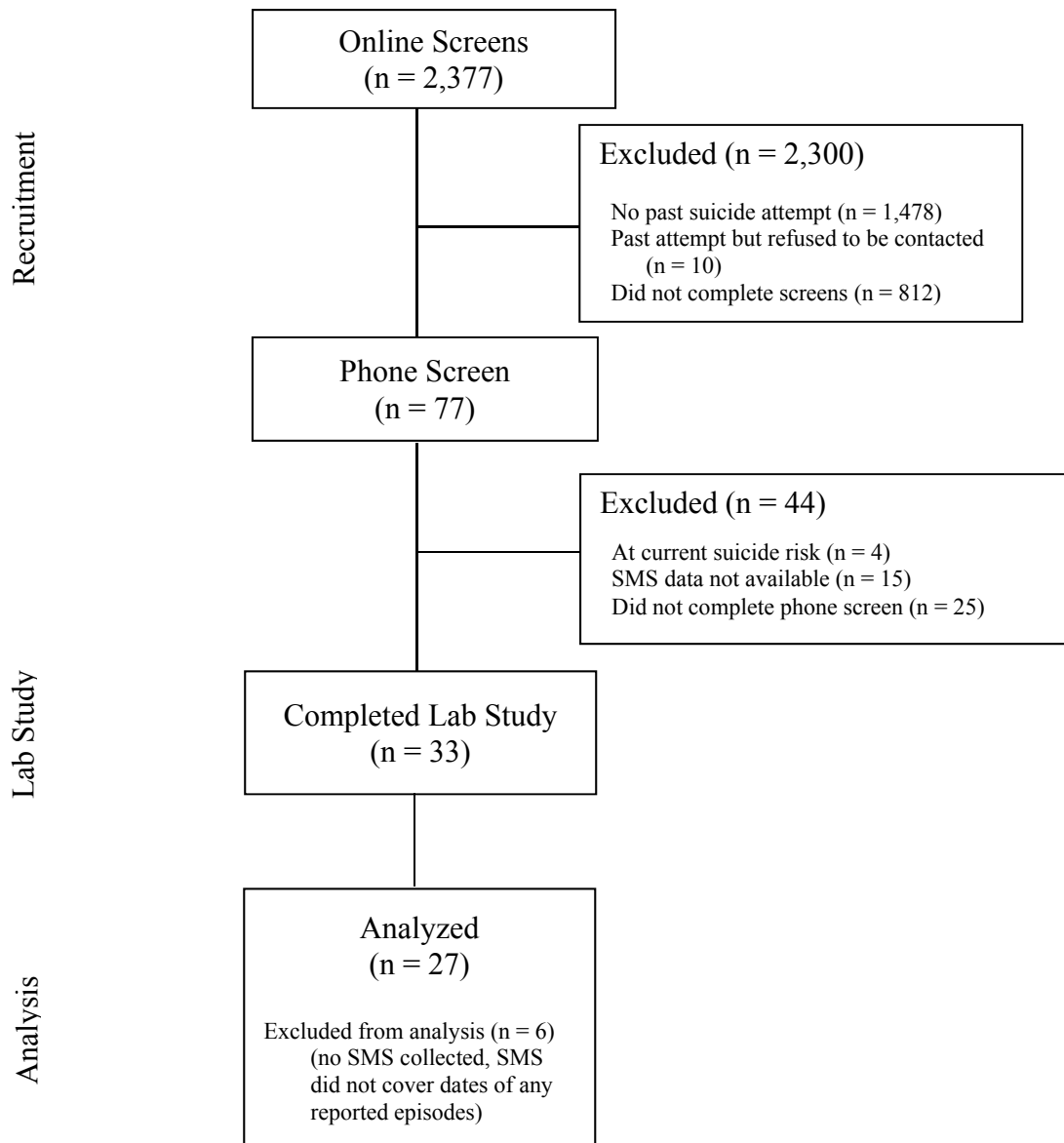


Figure 2. Example of temporal descriptive analyses

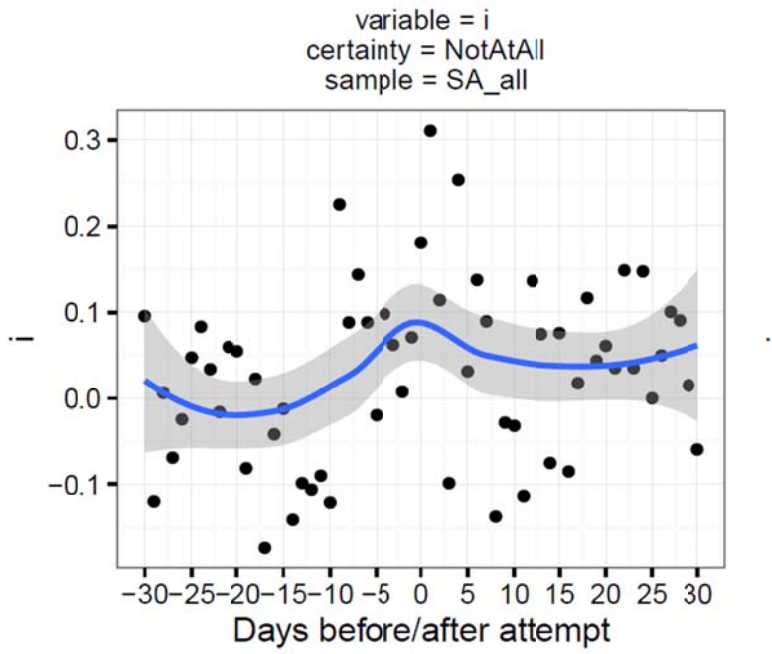


Figure 3A. Episode type differences in use of anxiety words for certain episodes only (note: error bars represent bootstrapped asymmetric confidence intervals based on the modeling output)

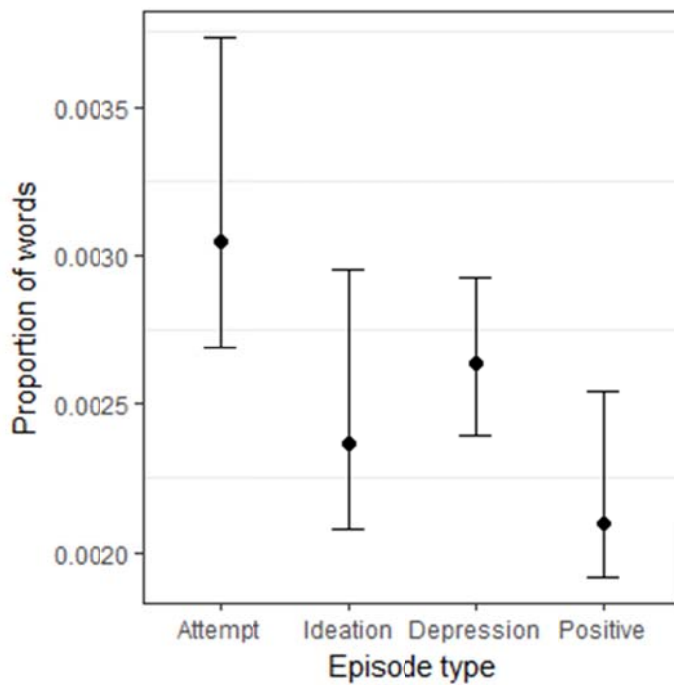


Figure 3B. Episode type differences in use of sad words (note: error bars represent bootstrapped asymmetric confidence intervals based on the modeling output)

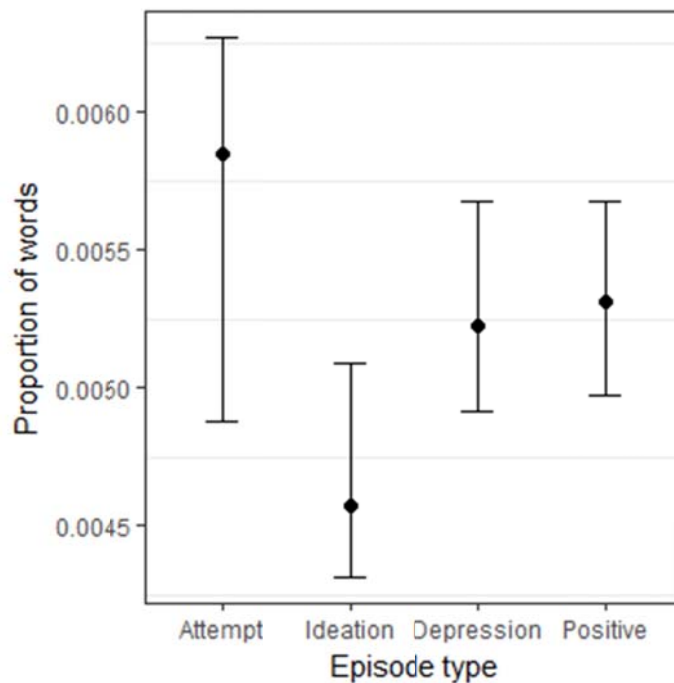


Figure 4A. Episode type differences for outgoing message counts for certain episodes only (note: error bars represent bootstrapped asymmetric confidence intervals based on the modeling output)

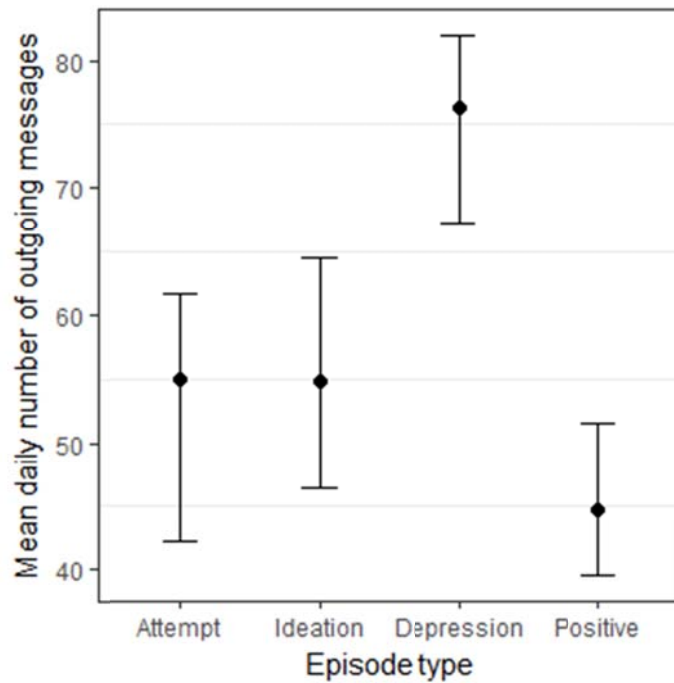


Figure 4B. Episode type differences for incoming message counts for certain episodes only (note: error bars represent bootstrapped asymmetric confidence intervals based on the modeling output)

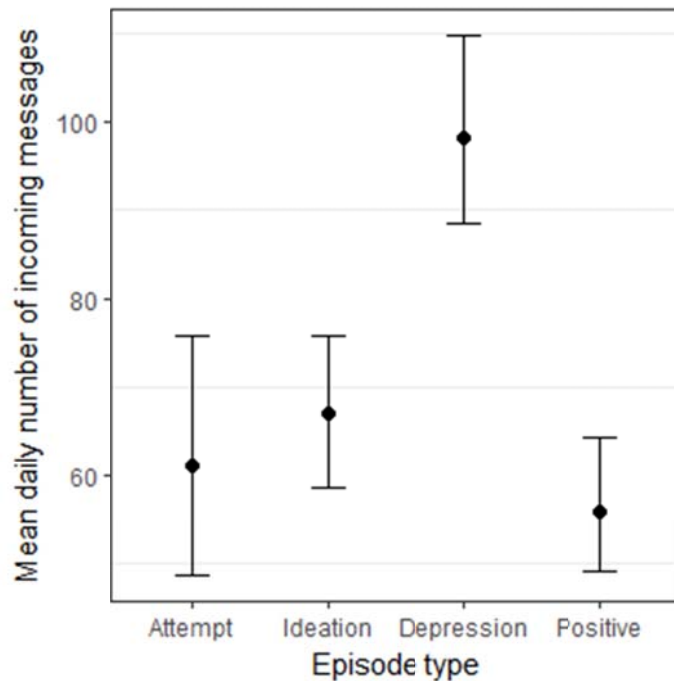


Figure 5. Episode type differences in use of future-oriented words (note: error bars represent bootstrapped asymmetric confidence intervals based on the modeling output)

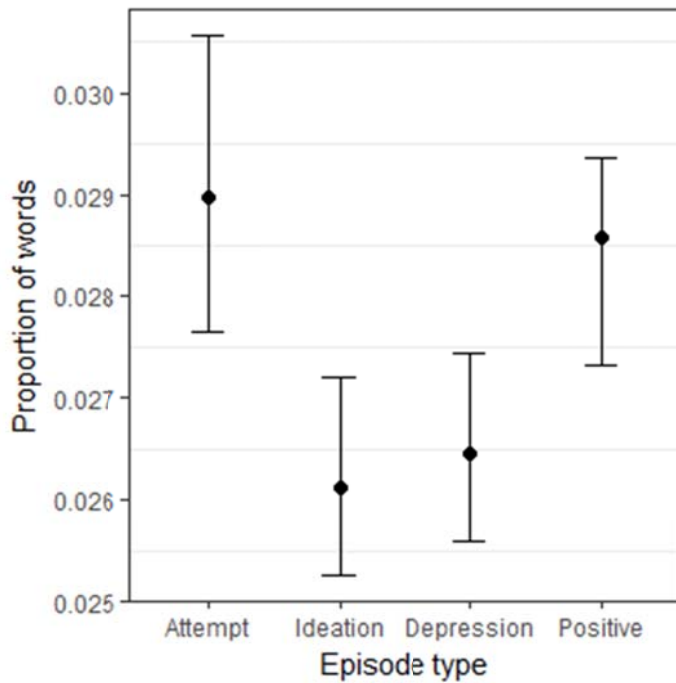


Figure 6A. Episode type differences in language complexity (analytical) scores (note: error bars represent bootstrapped asymmetric confidence intervals based on the modeling output)

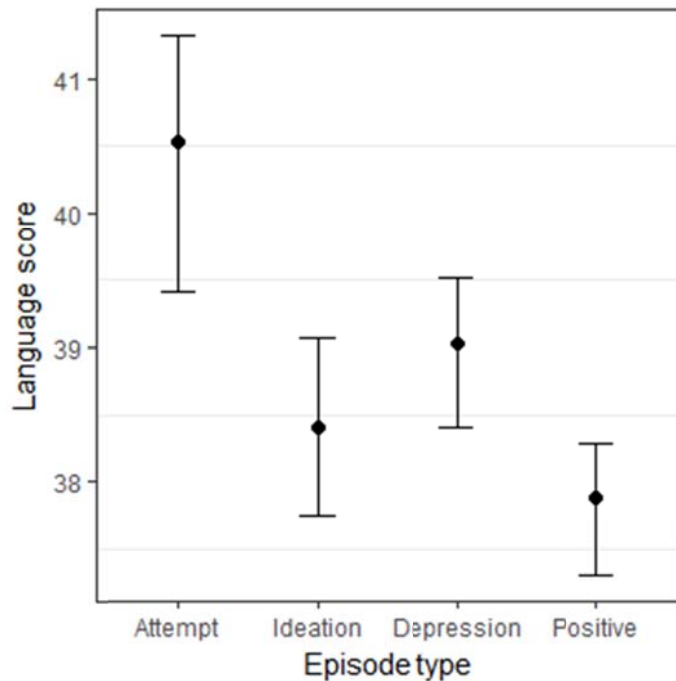


Figure 6B. Episode type differences in high-status language (clout) scores for certain episodes only
(note: error bars represent bootstrapped asymmetric confidence intervals based on the modeling output)

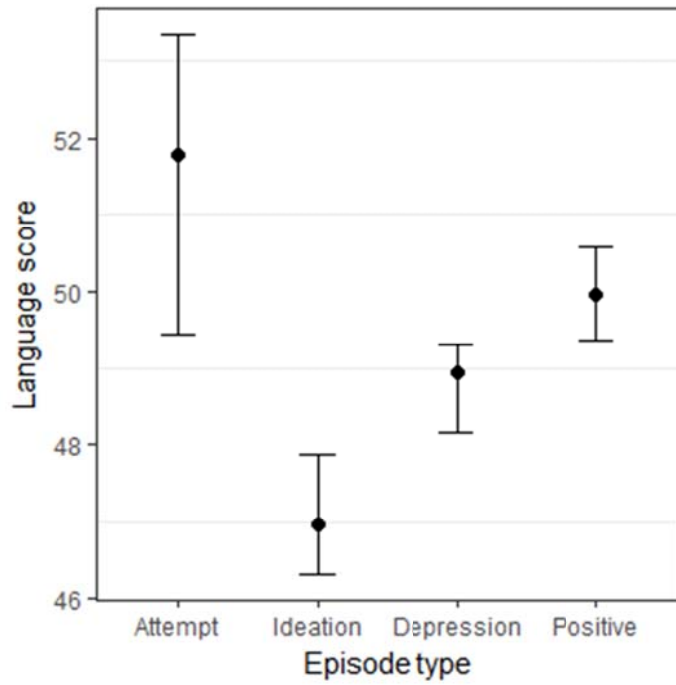


Figure 7. Differences in episode type \times day of episode interaction for first-person pronoun use

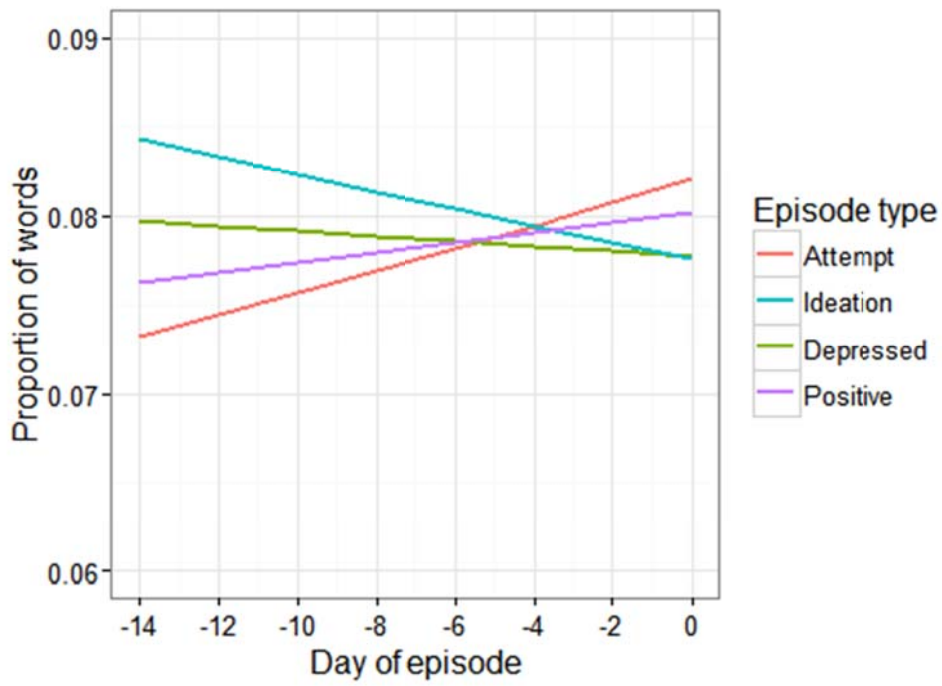


Figure 8A. Differences in episode type \times day of episode interaction for positive emotion

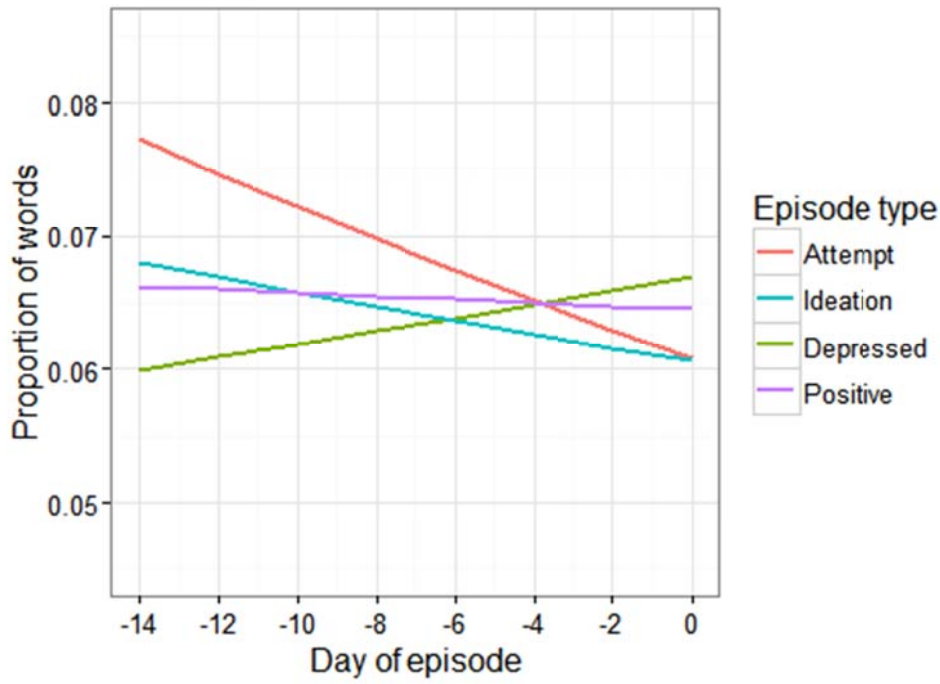


Figure 8B. Differences in episode type \times day of episode interaction for anger

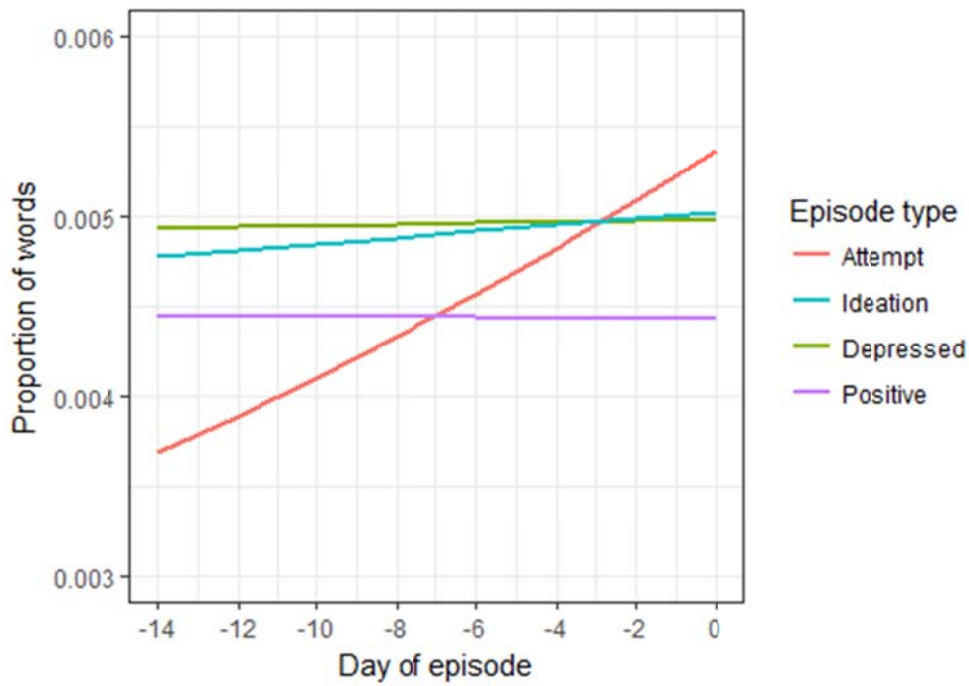


Figure 8C. Differences in episode type \times day of episode interaction for death words

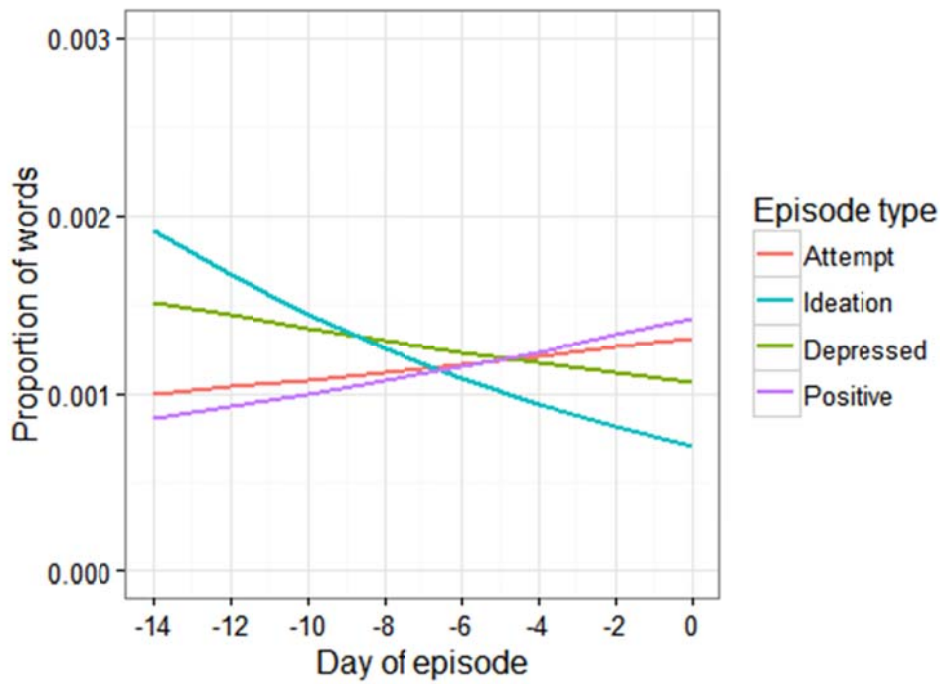


Figure 8D. Differences in episode type \times day of episode interaction for emotional tone

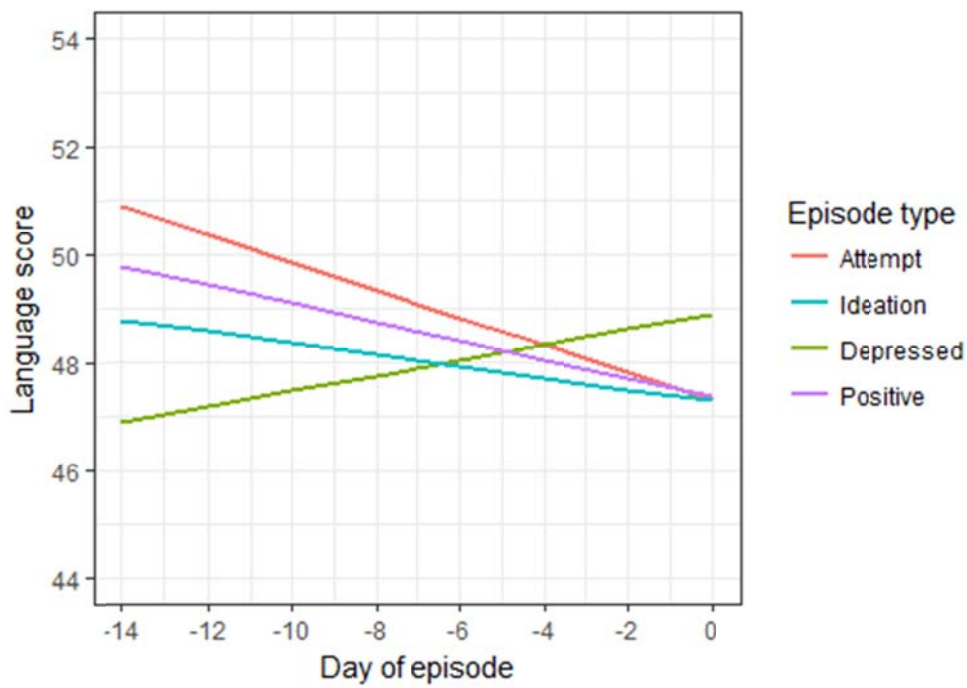


Figure 9. Differences in episode type \times day of episode interaction for future-oriented language

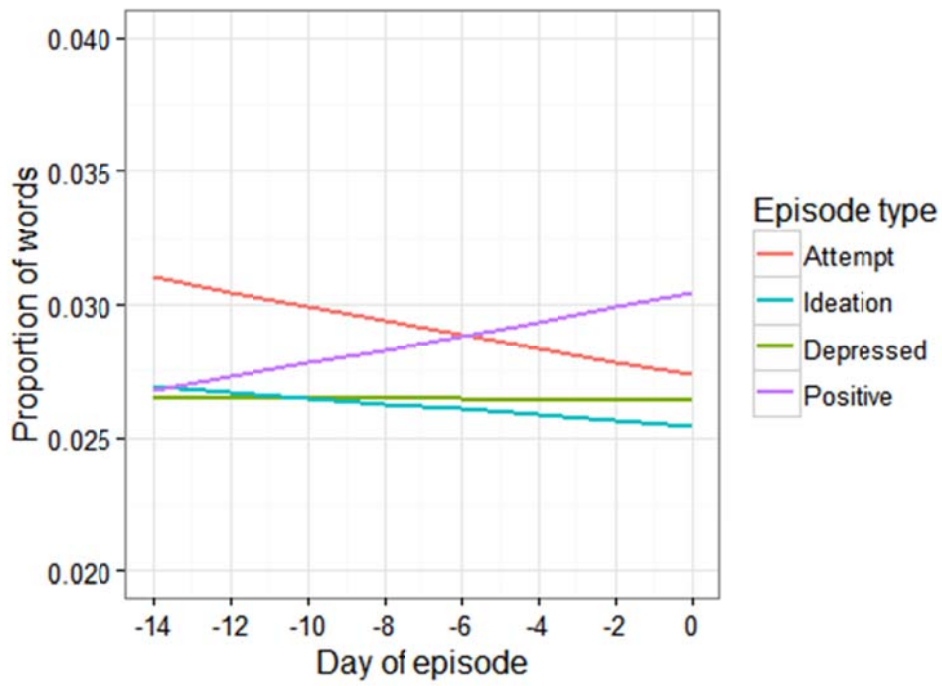
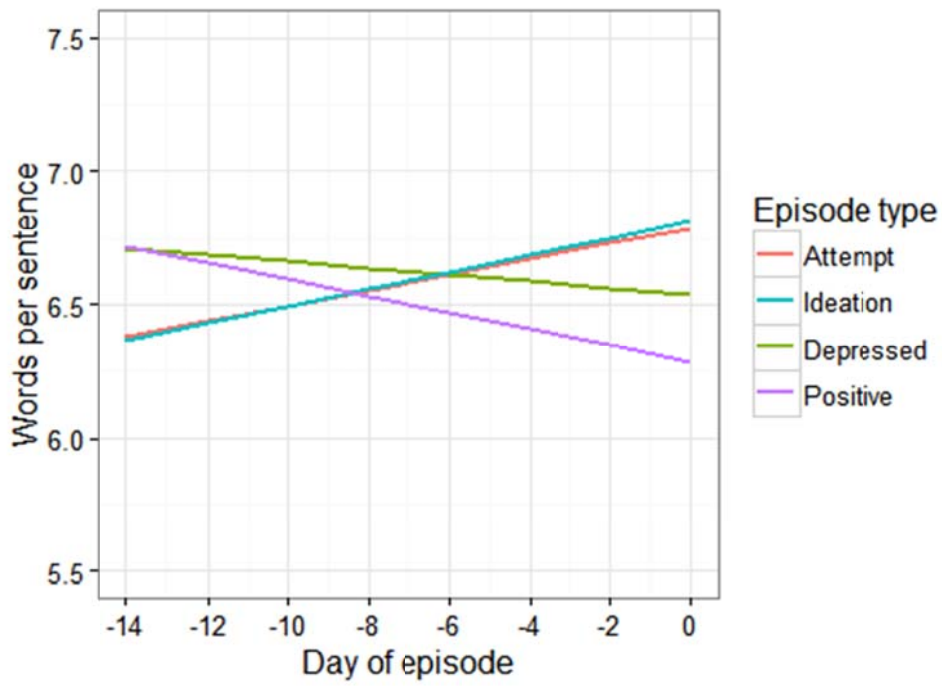
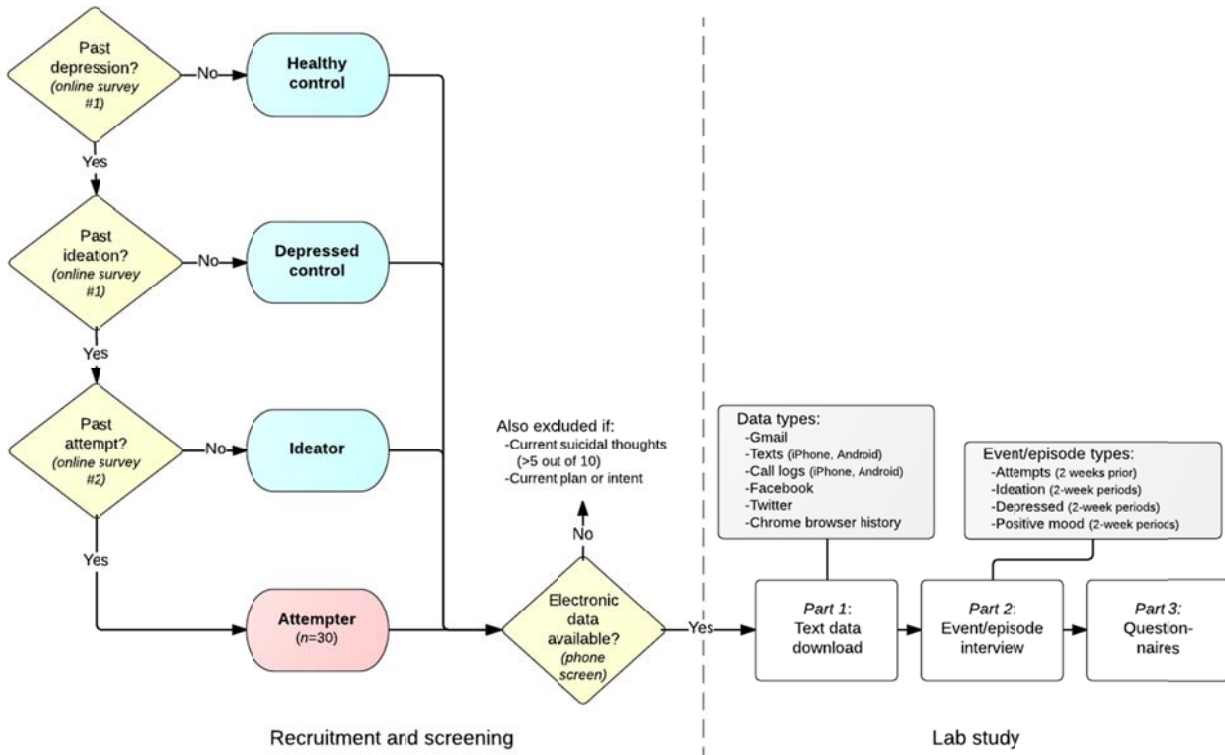


Figure 10. Differences in episode type \times day of episode interaction for words per sentence



Appendix A. Study design

Study procedure flowchart



Appendix B. Recruitment materials

Online Survey 1: History of past sadness

Q1. Have you ever had a period of sadness in the past during which you felt hopeless?

- Yes
- No
- Prefer not to answer

Q2. May we contact you about possible participation in studies that ask more questions about this period of time in your life? Saying yes simply means that we can tell you more about a given study and you can decide then if you want to participate – it does not mean you're committing to participate in any studies at this time. **[Only shown to respondents endorsing 'Yes' in Q1]**

- Yes
- No

Online Survey 2: Assessing suicidal history

We are studying sensitive topics, including the desire to hurt or kill oneself. While these sensitive topics can sometimes be difficult to talk about, it is very helpful for us to learn about people's experiences to ultimately improve prevention and care.

Enter the subject ID provided in the email: _____

Q1. Have you ever made a suicide attempt?

- Yes
- No
- Prefer not to answer

Q2. Have you ever had suicidal thoughts?

- Yes
- No
- Prefer not to answer

Q3. May we contact you to do a brief phone screen regarding possible participation in studies that ask more questions about your history of suicidal thoughts and behaviors? Saying yes simply means that we can tell you more about a given study and you can decide then if you want to participate – it does not mean you're committing to participate in any studies at this time. **[Only shown to respondents endorsing 'Yes' in Q1 and/or Q2]**

- Yes
- No

If you are currently experiencing suicidal thoughts and feel like you might act on these thoughts, we encourage you to do one or more of the following:

- Call a friend or family member
- Speak to an emergency clinician at CAPS (434-243-5150 on weekdays; **434-972-7004 after hours/weekends**)
- Call 1-800-SUICIDE
- Call 911 or visit the emergency department of a local hospital (UVa hospital emergency department located at 1215 Lee St., Charlottesville, VA 22908)

Appendix C. Sample data download instructions

Google Download Instructions
(Gmail, Google Hangouts/Gchat, and Google Search History)

Gmail data format: Each email includes a timestamp, subject, sender name and email address, recipient name and email address, message content, and other computer information specifying how the email was retrieved and should be displayed on the screen.

```
From 1445391128171571609@xxx Fri Sep 06 01:53:16 +0000 2013
X-GM-THRID: 1445391128171571609
X-Gmail-Label: Unread
MIME-Version: 1.0
Received: by 10.112.4.199; Thu, 5 Sep 2013 18:53:15 -0700 (PDT)
Date: Thu, 5 Sep 2013 18:53:15 -0700
Message-ID: <CAOuC6m30_GwzOJgRVbfn9LZJW+WPuhqsBP0pMQ1fbrJpw@mail.gmail.com>
Subject: Subject Line of the Email
From: Sender Name <someone@gmail.com>
To: Recipient Name <somebody@gmail.com>
Content-Type: multipart/alternative; boundary=001a11c327864c409004e5ad4de8

--001a11c327864c409004e5ad4de8
Content-Type: text/plain; charset=windows-1252
Content-Transfer-Encoding: quoted-printable

Hello Recipient,

This is an example email message.
This is more text as an example.
And even more.

Sincerely,
Sender

--001a11c327864c409004e5ad4de8
```

Google Hangouts/Gchat data format: Each gchat or hangout has a timestamp, the content of the typed message, and various computer-generated codes that do not contain names or email addresses.

```
"conversation_id" :
  "id" : "UgxIxa9kg_SfILSrrKF4AaABAQ"
  "timestamp" : "1368748647545204"
  "sender_id" : "113823739616675880984"
  "user_id" : "113823739616675880984"
  "client_generated_id" : "18446744073521511356"
  "notification_level" : "RING"
"chat_message" :
  "type" : "TEXT"
  "text" : "This is an example of gchat text."
  "event_id" : "7-HOZ7-PLIN7-H8xi pQC08"
  "advances_sort_timestamp" : true
  "event_otr" : "ON_THE_RECORD"
  "event_type" : "REGULAR_CHAT_MESSAGE"
  "event_version" : "1368748647545204"
```

Google Search History data format: each search has a timestamp and the search terms

```
[{"query": {"id": [{"timestamp_usec": "1380148194481759"}, "query_text": "search text example 1"}],
{"query": {"id": [{"timestamp_usec": "1380140156470040"}, "query_text": "search text example 2"}],
{"query": {"id": [{"timestamp_usec": "1380138128941166"}, "query_text": "search text example 3"}]
```

Appendix D. Frequent recipients of electronic communication

Instructions:

1. Please list at **least 5 (and up to 10) people** with whom you most frequently communicate electronically **over the past few years**, starting with the most frequent first. This information will help us better understand if and how your communication patterns change at different periods during your life.
2. Please also say **how they are related to you**. Relationship options (choose most specific term):
 - **Family:** mother, father, sister, brother, son, daughter, spouse, girlfriend, boyfriend
 - **Friend:** best friend, close friend, friend (not esp. close), acquaintance, neighbor
 - **Work/School:** coworker, classmate, boss/supervisor
 - **Other:** please specify
3. Circle the **methods** you are most likely to communicate with them.
4. List all of their **email addresses, phone numbers, and social media names**.
5. Among the people you list, please list the **3 contacts** with whom you are **most emotionally expressive**.

Contact #1	
<p>Name: _____</p> <p>Relationship to you: _____</p> <p>Main ways you communicate with person (<i>check all that apply</i>):</p> <p> <input type="checkbox"/> Email <input type="checkbox"/> Texts <input type="checkbox"/> Facebook <input type="checkbox"/> Twitter <input type="checkbox"/> Gchat <input type="checkbox"/> Phone <input type="checkbox"/> Other _____ </p>	<p>Email address(es):</p> <p>Personal: _____</p> <p>Work: _____</p> <p>Phone(s):</p> <p>Cell: _____</p> <p>Work: _____</p> <p>Home: _____</p> <p>Facebook name: _____</p> <p>Twitter handle: _____</p>

Appendix E. Episode interview

Interview sections administered for each episode type

Suicide attempt	Ideation episode	Depressive episode	Positive episode
Attempt			
Interrupted/aborted attempts	Interrupted/aborted attempts		
Plan	Plan		
Ideation (also post-attempt)	Ideation	Ideation	
Circumstances leading to outcome	Circumstances leading to outcome	Circumstances leading to outcome	
Depression (also post-attempt)	Depression	Depression	Depression
Mood (also post-attempt)	Mood	Mood	Mood
Treatment (also post-attempt)	Treatment	Treatment	Treatment
Drugs/alcohol	Drugs/alcohol	Drugs/alcohol	Drugs/alcohol

Interview for suicide attempts**ACTUAL ATTEMPT:**

Have you ever made an actual attempt to kill yourself, meaning you engaged in a potentially deadly behavior to end your life with some intention of dying?

For example, (1) you went to a bridge and jumped off, (2) took out pills and you took them, (3) took out a gun and pulled the trigger.

- Yes
- No
- Not sure

How many suicide attempts have you made in your lifetime?

(#) _____

INTERRUPTED ATTEMPT:

Has there ever been a time when you started to take steps to kill yourself but, at the last minute, someone or something stopped you before you actually did anything?

For example, (1) you went to a bridge but someone stopped you before you jumped off, (2) took out pills but someone stopped you before you took them, (3) took out a gun but someone stopped you before you pulled the trigger.

- Yes
- No
- Not sure

How many times in your lifetime have you started to do something to kill yourself but but someone or something stopped you before you actually did anything?

(#) _____

ABORTED ATTEMPT:

Has there ever been a time when you started to take steps to kill yourself but, at the last minute, you stopped yourself before you actually did anything?

For example, (1) you went to a bridge but did not jump off, (2) took out pills but did not take them, (3) took out a gun but did not pull the trigger.

- Yes
- No
- Not sure

How many times in your lifetime have you started to do something to kill yourself but you stopped yourself before you actually did anything?

(#) _____

ATTEMPT DETAILS:

Now I'll ask you questions to learn more about this/these suicide attempt(s), including how you felt leading up to and after the/each attempt. [If multiple attempts: Let's start first with your most recent attempt.]

What was the date of this suicide attempt? (use format: 01/01/2016)

(Date) _____

How certain are you that this was the actual date of the attempt?

- Very certain (this is the exact date)
- Somewhat certain (the actual date may be off by a few days)
- Not very certain (the actual date may be off by a week or two)
- Not at all certain (the actual date may be off by over two weeks)
- Other _____

P answers following questions on the computer on their own.

METHOD:

For this suicide attempt, what method(s) did you use? (check all that apply)

- own prescription drugs
- illicit drugs (not prescribed)
- over-counter drugs
- other's prescription drugs
- poison
- firearms
- immolation
- sharp object
- auto exhaust
- other gases
- train/car
- jump from height
- drowning
- suffocation
- hanging
- other _____

INTENT:

Right before you attempted, how much did you want to die?

- Definitely did not want to die
- Fairly sure did not want to die
- Not sure wanted to live or die
- Fairly sure did want to die
- Definitely did want to die
- Not applicable/choose not to answer

LETHALITY (SUBJECTIVE):

Just before the attempt, how certain were you that you would die from this suicide attempt?

- I was extremely certain I would live
- I was fairly certain I would live
- I thought it was equally likely that I would live or die
- I was fairly certain I would die
- I was extremely certain I would die
- Other (please explain) _____

LETHALITY (OBJECTIVE):

What medical or physical damage occurred as a result of this suicide attempt?

- No physical damage or very minor physical damage (e.g., surface scratches).
- Minor physical damage (e.g., lethargic speech; first-degree burns; mild bleeding; sprains).
- Moderate physical damage; medical attention needed (e.g., conscious but sleepy, somewhat responsive; second-degree burns; bleeding of major vessel).
- Moderately severe physical damage; medical hospitalization and likely intensive care required (e.g., comatose with reflexes intact; third-degree burns less than 20% of body; extensive blood loss but can recover; major fractures).
- Severe physical damage; medical hospitalization with intensive care required (e.g., comatose without reflexes; third-degree burns over 20% of body; extensive blood loss with unstable vital signs; major damage to a vital area).

DRUGS/ALCOHOL:

Were you drinking alcohol when you attempted suicide?

- Yes
- No
- Not sure

How many drinks did you have the day of the suicide attempt?

(#) _____

Were you using illegal or illicit drugs the day of the suicide attempt?

- Yes
- No
- Not sure

Indicate which drugs you had taken at the time of the attempt and how much you used the day of the attempt.

	Taking the day of the attempt (select all that apply)	Total amount of drug used the day of the attempt
Tobacco	<input type="checkbox"/>	_____
Marijuana/Cannabis	<input type="checkbox"/>	_____
“Powder” Cocaine	<input type="checkbox"/>	_____
“Crack” Cocaine	<input type="checkbox"/>	_____
Amphetamines (SPEED)	<input type="checkbox"/>	_____
Methamphetamines (METH)	<input type="checkbox"/>	_____
Ecstasy (other “Club” Drugs)	<input type="checkbox"/>	_____
Heroin	<input type="checkbox"/>	_____
Methadone (non-prescription or street drugs)	<input type="checkbox"/>	_____
Other Opiates or “Pain Killers” (non-prescription or street drugs)	<input type="checkbox"/>	_____
Barbiturates (non-prescription or street drugs)	<input type="checkbox"/>	_____
Sedatives/Hypnotics or Tranquilizers (non-prescription or street drugs)	<input type="checkbox"/>	_____
Inhalants (Cleansers, Paint, etc.)	<input type="checkbox"/>	_____
Hallucinogens	<input type="checkbox"/>	_____
Over-the-counter drugs	<input type="checkbox"/>	_____
Other	<input type="checkbox"/>	_____

SUICIDE PLANNING:

Prior to attempting suicide, did you make an actual plan to kill yourself? This means deciding how or where to try to kill yourself.

- Yes
- No
- Not sure

Once you had a plan, how long did you think about it before you actually attempted to kill yourself?

- 0 seconds
- 1-60 seconds

- 2-15 minutes
- 16-60 minutes
- less than one day
- 1-2 days
- 3-6 days
- 1-2 weeks
- other (if more than 2 days, please specify the exact date) _____
- not sure

How long was it from the time you made the final decision to try to kill yourself to when you actually attempting to kill yourself?

- 0 seconds
- 1-60 seconds
- 2-15 minutes
- 16-60 minutes
- less than one day
- 1-2 days
- 3-6 days
- 1-2 weeks
- other (if more than 2 days, please specify the exact date) _____
- not sure

CIRCUMSTANCES:

What were the circumstances that contributed most to this attempt? (select all that apply)

- job loss/stress/academic failure
- problems with family or friends
- problems with spouse/lover
- financial problems
- eviction
- health problems
- death of another person
- psychiatric symptoms
- humiliating event
- loneliness
- other (please specify) _____

Please rank in order of importance the circumstances that contributed most to this suicide attempt.

The following questions refer to the two weeks *prior* to the suicide attempt.

TREATMENT:

During the two weeks prior to your suicide attempt, did you get help for mental or emotional difficulties from any of the following? Please select all that apply, or select “I did not receive help.”

- Psychiatrist
- Psychologist
- School counselor
- Licensed mental health practitioner (LMHC)
- General practitioner (e.g. family doctor)
- Teacher
- Family member
- Friend
- Religious Leader
- Coach
- Self-help book
- Prescription medication
- Other
- I did not receive help

IDEATION:

During these two weeks, did you think of any of the following for longer than a few minutes (more than fleeting thoughts):

	Yes	No	Prefer not to respond
I wish I could disappear or not exist	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I wish I was dead (for example go to sleep and not wake up again)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Maybe I should kill myself	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

During this two-week period of having suicidal thoughts, how intense or severe were your thoughts of wanting to kill yourself?

	At the worst point	On average
Not at all intense	<input type="radio"/>	<input type="radio"/>
A little intense	<input type="radio"/>	<input type="radio"/>
Somewhat intense	<input type="radio"/>	<input type="radio"/>
Very intense	<input type="radio"/>	<input type="radio"/>
Extremely intense	<input type="radio"/>	<input type="radio"/>

How many times did you have suicidal thoughts during these two weeks?

- Less than once a week
- Once a week
- 2-5 times in week
- Daily or almost daily
- Many times each day

When you had suicidal thoughts during these two weeks, how long did they usually last?

- Fleeting - few seconds or minutes
- Less than 1 hour/some of the time
- 1-4 hours/a lot of time
- 4-8 hours/most of day
- More than 8 hours/persistent or continuous

DEPRESSION:

During these two weeks, did you feel depressed, empty, hopeless, or lost interest or pleasure in your usual activities, most of the day nearly every day?

- Yes
- No
- Not sure

During these 2 weeks, how often were you bothered by the following problems?

	Not at All	Several Days	More Than Half the Days	Nearly Every Day
Feeling nervous, anxious, or on edge	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not being able to stop or control worrying	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feeling down, depressed, or hopeless	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Little interest or pleasure in doing things	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

MOOD:

During the two weeks prior to your suicide attempt, to what extent did you feel the following feelings and emotions?

	very slightly or not at all	a little	moderately	quite a bit	extremely
Scared	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Angry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ashamed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Alone	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Joyful	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Daring	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Determined	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Timid	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Calm	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Surprised	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Appendix F. Linguistic Inquiry and Word Count (LIWC) dictionary and categories

Information about from the LIWC2015 Language Manual (Pennebaker et al., 2015), which will be used to create feature vectors for a machine learning algorithm that attempts to classify suicide attempts.

The LIWC2015 Dictionary is the heart of the text analysis strategy. The default LIWC2015 Dictionary is composed of almost 6,400 words, word stems, and select emoticons. Each dictionary entry additionally defines one or more word categories or subdictionaries. For example, the word cried is part of five word categories: sadness, negative emotion, overall affect, verbs, and past focus. Hence, if the word cried is found in the target text, each of these five subdictionary scale scores will be incremented. As in this example, many of the LIWC2015 categories are arranged hierarchically. All sadness words, by definition, belong to the broader “negative emotion” category, as well as the “overall affect words” category. Note too that word stems can be captured by the LIWC2015 system. For example, the dictionary includes the stem hungri which allows for any target word that matches the first five letters to be counted as an ingestion word (including hungry, hungrier, hungriest). The asterisk, then, denotes the acceptance of all letters, hyphens, or numbers following its appearance.*

Each of the default LIWC2015 categories is composed of a list of dictionary words that define that scale. Table 1 provides a comprehensive list of the default LIWC2015 dictionary categories, scales, sample scale words, and relevant scale word counts.

Category	Abbrev	Examples	Words in category
Word count	WC	-	-
Summary Language			
Analytical thinking	Analytic	-	-
Clout	Clout	-	-
Authentic	Authentic	-	-
Emotional tone	Tone	-	-
Words/sentence	WPS	-	-
Words > 6 letters	Sixltr	-	-
Dictionary words	Dic	-	-
Linguistic Dimensions			
Total function words	funct	it, to, no, very	491
Total pronouns	pronoun	I, them, itself	153
Personal pronouns	ppron	I, them, her	93
1st pers singular	i	I, me, mine	24
1st pers plural	we	we, us, our	12
2nd person	you	you, your, thou	30
3rd pers singular	shehe	she, her, him	17
3rd pers plural	they	they, their, they'd	11
Impersonal pronouns	ipron	it, it's, those	59
Articles	article	a, an, the	3
Prepositions	prep	to, with, above	74
Auxiliary verbs	auxverb	am, will, have	141
Common Adverbs	adverb	very, really	140
Conjunctions	conj	and, but, whereas	43
Negations	negate	no, not, never	62
Other Grammar			
Common verbs	verb	eat, come, carry	1000
Common adjectives	adj	free, happy, long	764
Comparisons	compare	greater, best, after	317
Interrogatives	interrog	how, when, what	48
Numbers	number	second, thousand	36
Quantifiers	quant	few, many, much	77
Psychological Processes			
Affective processes	affect	happy, cried	1393
Positive emotion	posemo	love, nice, sweet	620
Negative emotion	negemo	hurt, ugly, nasty	744
Anxiety	anx	worried, fearful	116
Anger	anger	hate, kill, annoyed	230
Sadness	sad	crying, grief, sad	136
Social processes	social	mate, talk, they	756
Family	family	daughter, dad, aunt	118
Friends	friend	buddy, neighbor	95
Female references	female	girl, her, mom	124
Male references	male	boy, his, dad	116

Category	Abbrev	Examples	Words in category
Cognitive processes	cogproc	cause, know, ought	797
Insight	insight	think, know	259
Causation	cause	because, effect	135
Discrepancy	discrep	should, would	83
Tentative	tentat	maybe, perhaps	178
Certainty	certain	always, never	113
Differentiation	differ	hasn't, but, else	81
Perceptual processes	percept	look, heard, feeling	436
See	see	view, saw, seen	126
Hear	hear	listen, hearing	93
Feel	feel	feels, touch	128
Biological processes	bio	eat, blood, pain	748
Body	body	cheek, hands, spit	215
Health	health	clinic, flu, pill	294
Sexual	sexual	horny, love, incest	131
Ingestion	ingest	dish, eat, pizza	184
Drives	drives		1103
Affiliation	affiliation	ally, friend, social	248
Achievement	achieve	win, success, better	213
Power	power	superior, bully	518
Reward	reward	take, prize, benefit	120
Risk	risk	danger, doubt	103
Time orientations	TimeOrient		
Past focus	focuspast	ago, did, talked	341
Present focus	focuspresent	today, is, now	424
Future focus	focusfuture	may, will, soon	97
Relativity	relativ	area, bend, exit	974
Motion	motion	arrive, car, go	325
Space	space	down, in, thin	360
Time	time	end, until, season	310
Personal concerns			
Work	work	job, majors, xerox	444
Leisure	leisure	cook, chat, movie	296
Home	home	kitchen, landlord	100
Money	money	audit, cash, owe	226
Religion	relig	altar, church	174
Death	death	bury, coffin, kill	74
Informal language	informal		380
Swear words	swear	fuck, damn, shit	131
Netspeak	netspeak	btw, lol, thx	209
Assent	assent	agree, OK, yes	36
Nonfluencies	nonflu	er, hm, umm	19
Fillers	filler	I mean, you know	14

Appendix G. Questionnaires

Demographics Information

Demo1 What is your birth date? (MM/DD/YYYY)

Demo2 What is your gender?

- Male
- Female
- Prefer not to answer or other (please specify): _____

Demo3 I would describe my race/ethnic group as (choose all that apply):

- American-Indian/Alaskan Native
- Asian
- Black or African American
- Hispanic or Latino
- Native Hawaiian or Other Pacific Islander
- White
- Other _____
- Prefer not to answer

Demo4 Please indicate your citizenship status:

- U.S. Citizen or Permanent Resident
- Non-U.S. Citizen or Permanent Resident

Demo5 What is the highest level of education you have completed?

- Less than High School
- High School / GED
- Some College
- Associate's Degree
- Bachelor's Degree
- Some Graduate School
- Master's Degree
- Doctoral Degree
- Professional Degree (JD, MD)

Demo6 Do you consider yourself to be:

- Heterosexual/Straight
- Gay/Lesbian/Homosexual
- Bisexual
- Other _____
- Decline to state

Demo7 What is your marital status?

- Single (never married)
- In relationship (not living with partner)
- In relationship (living with partner)
- Married
- Divorced
- Separated
- Widowed

Demo8 Please indicate your employment status:

- Student
- Full-time employment
- Part-time employment
- Self-employed
- Out of work and looking for work
- Out of work but not currently looking for work
- Homemaker
- Military
- Retired
- Unable to work

Demo9 What is your living situation?

- Live alone
- Live with roommate(s)
- Live with partner
- Other _____

Mental Health and Treatment History Questionnaire

MHH1 Are you currently, or have you ever struggled with moderate to severe mental or emotional difficulties (e.g. depression, panic attacks, anxiety, fighting a lot with family or friends, problems in school, etc.) that lasted a minimum of several weeks and interfered with your daily life?

- Yes
- No
- Prefer not to answer

MHH2 Have you ever been diagnosed with any of the following psychiatric disorders? Please check all that apply.

- Depressive disorder
- Bipolar disorder (or mania)
- Panic disorder
- Agoraphobia
- Social phobia or anxiety
- Obsessive-compulsive disorder (OCD)
- Posttraumatic stress disorder (PTSD)
- Alcohol abuse or dependence
- Substance abuse or dependence
- Psychotic disorder
- Anorexia nervosa
- Bulimia nervosa
- Generalized anxiety disorder (GAD)
- Borderline personality disorder
- Other (please specify): _____
- I have never been diagnosed with any of the above

MHH3 Among the disorders you endorsed, which of the following are you currently diagnosed with?

MHH4 The next questions are about emotional problems you may have had. Have you had problems with the following issues that lasted more than 1 month and were so bad that they caused problems for you at work/school, with your family, or friends? If so, when was the last time?

	Past week	Past year (not past week)	More than a year ago	Never
1. you were so sad or depressed that you couldn't concentrate, had trouble eating or sleeping, or didn't want to do things you usually enjoy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. you were hyper or manic; that is, much more excited and full of energy than usual, your mind went too fast, and you did things that were unusual for you (for example, taking risks, spending too much money)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. you had insomnia, or problems falling asleep, staying asleep, or waking up too early	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. you had repeated attacks of fear or panic when all of a sudden you felt very frightened, anxious, or uneasy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. you had repeated attacks of anger when all of a sudden you lost control and broke or smashed something, hit or tried to hurt someone, or threatened someone	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. after a traumatic experience, you had frequent upsetting memories or dreams, felt jumpy, distant or depressed, and had trouble sleeping or concentrating. (Do not report the most recent time a traumatic experience occurred, but rather the most recent time you had reactions of the sort described here to a traumatic experience.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. you were so agitated, anxious, or worried that you couldn't relax, sleep, or concentrate, and you couldn't function normally	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8. you used alcohol so much that it got you in trouble at work/school or with family/friends, or your use was out of control	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9. you used drugs (for example, marijuana, cocaine, etc.) so much that it got you in trouble at work/school or with family/friends, or your use was out of control	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10. you had unusual experiences like seeing or hearing things that other people couldn't see or hear. (Do not include times when you were half-asleep or drinking alcohol or taking drugs.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

11. you had strange thoughts like believing your mind was being controlled by outside forces, that someone or something was sending you special signs (like through the TV), or that someone or something was plotting to harm you	○	○	○	○
------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	---	---	---	---

MHH5 Have you ever seen and gotten help for mental or emotional difficulties from any of the following? Please select all that apply, or select "I did not receive help".

- Psychiatrist
- Psychologist
- School counselor
- Licensed mental health practitioner (LMHC)
- General practitioner (e.g. family doctor)
- Teacher
- Family member
- Friend
- Religious Leader
- Coach
- Self-help book
- Prescription medication
- Other _____
- I did not receive help

MHH6 Please list the approximate dates during which you have received treatment and whether you are seeing them currently.

MHH7 Have you ever gone to an emergency room for help with emotional or behavioral problems?

- Yes
- No
- Prefer not answer

MHH8 How many separate times have you ever gone to an emergency room for help with emotional or behavioral problems?

MHH9 Have you ever been admitted for an overnight stay at a hospital for the treatment of emotional or behavioral problems?

- Yes
- No
- Prefer not to answer

MHH10 How many separate times have you ever been admitted for an overnight stay at a hospital for the treatment of emotional or behavioral problems?

MHH11 Are you currently taking any medications for depression, anxiety, or another psychological condition?

- Yes
- No
- Prefer not to answer

MHH12 For each medication you are taking currently, please list medication name and duration of time on the medication.

Self-Injurious Thoughts and Behaviors Interview (SITBI)

SITBI1 For the next few questions, we will be asking about times when you have purposely hurt yourself without wanting to die, including things like cutting or burning your skin. In answering these questions, please do not include times where you have hurt yourself in minor ways, like picking at wounds, biting your lips or nails, or getting tattoos or piercings. Also, do not include times when you have indirectly hurt yourself, such as starving yourself or overdosing without wanting to die.

SITBI2 Have you ever purposely hurt yourself without wanting to die?

- No
- Yes

SITBI3 What are the ways in which you have purposely hurt yourself without wanting to die? Please select each of these you've done:

- Cut or carved skin
- Hit yourself on purpose
- Burned your skin
- Inserted sharp objects into your skin or nails
- Bit yourself
- Scraped your skin to the point of drawing blood
- other _____
- other _____
- other _____
- other _____

SITBI4 For the following questions, please make your best guess if you're not sure of the exact age.

- How old were you the first time you purposely hurt yourself without wanting to die?
- How old were you the last time?

SITBI5 Please give your best estimate for the following questions.

- In the past week, how many times have you purposely hurt yourself without wanting to die?
- In the past month, how many times have you purposely hurt yourself without wanting to die?
- In the past year, how many times have you purposely hurt yourself without wanting to die?
- How many times in your life have you purposely hurt yourself without wanting to die?

SITBI6 Have you ever had thoughts of killing yourself?

- No
- Yes

SITBI7 Have you ever seriously considered killing yourself?

- No
- Yes

SITBI8 Please select each of the following thoughts that you've ever had. (If you have never had any of them, select 'None of these'.)

	Yes
"I wish I could disappear or not exist."	<input type="checkbox"/>
"I wish I were never born."	<input type="checkbox"/>
"My life is not worth living."	<input type="checkbox"/>
"I wish I would go to sleep and never wake up again."	<input type="checkbox"/>
"I wish I were dead."	<input type="checkbox"/>
"Maybe I should kill myself"	<input type="checkbox"/>
"I should kill myself."	<input type="checkbox"/>
"I am going to kill myself."	<input type="checkbox"/>
None of these.	<input type="checkbox"/>

SITBI9 Which of these thoughts have you had that lasted for more than a few minutes? (Select all that apply)

SITBI10

How old were you the first time you had thoughts like this?

How old were you the last time you had thoughts like this?

SITBI11 Please give your best estimate for the following questions.

In the past week, on how many days did you have these thoughts (0-7)?

In the past month, on how many days did you have these thoughts (0-31)?

In the past year, on how many days did you have these thoughts (0-365)?

In the past year, during how many months did you have these thoughts (0-12)?

How many days in your life have you had these thoughts?

SITBI12 Thinking about all of the times that you have had these thoughts, on average, how frequently did you have these thoughts?

- Every or nearly every day
- 3-4 days a week
- 1-2 days a week
- 1-2 days a month
- Less than once a month
- 1-2 days per year
- Less than once a year
- Never

SITBI13 Thinking about all of the times that you have had thoughts like this, how long did these thoughts usually last each time?

- 0 seconds
- 1-59 seconds

- 1-15 minutes
- 16-60 minutes
- Less than one day
- 1-2 days
- 3-6 days
- 1-2 weeks
- 2+ weeks
- Wide range (spans > 2 responses)

SITBI14 Thinking about all of the times that you have had thoughts like this, on average, how strong was the urge to kill yourself on a scale from 0-4?

SITBI15 Thinking about all of the times that you have had thoughts like this, at the worst point, how strong was the urge to kill yourself on a scale from 0-4?

SITBI16 The next couple of questions ask about suicide planning. You'll be asked about different aspects of planning, such as whether you've ever thought of how, where, or when to kill yourself.

SITBI17 Have you ever thought of a way or a method to kill yourself?

- No
- Yes

SITBI18 What method(s) did you think of using? Select all that apply.

- overdose
- cutting
- auto exhaust
- other gases
- poison
- firearms
- hanging
- suffocation
- stepping in front of a train/car
- crashing a car
- jumping from a height
- drowning
- other _____

SITBI19 Have you ever thought of a specific place to kill yourself?

- No
- Yes

SITBI20 Have you ever thought of a specific time to kill yourself?

- No
- Yes

SITBI21

How old were you the first time you thought of a suicide plan (method, place, or time)
How old were you the last time you thought of a suicide plan (method, place, or time)

SITBI22 Please give your best estimate for the following questions.

In the past week, on how many days did you think about your suicide plan(s)?
In the past month, on how many days did you think about your suicide plan(s)?
In the past year, on how many days did you think about your suicide plan(s)?
In the past year, during how many months did you think about your suicide plan(s) (0-12)?
How many days in your life did you think about your suicide plan(s)?
How many separate periods in your life have you thought about your suicide plans?

SITBI23 On a scale from 0-4, at the worst point, how seriously did you consider acting on your suicide plan(s)?

SITBI24 The following questions have to do with times you have said or done something to purposely lead someone to believe that you wanted to kill yourself when you really had no intention of dying. NOTE: This only refers to times where you have said or done things to purposely make people believe you wanted to kill yourself when you had no intention of doing so.

SITBI25 Have you ever said or done something to purposely lead someone to believe that you wanted to kill yourself when you really had no intention of dying?

- No
- Yes

SITBI26

How old were you the first time you said or did something like this?
How old were you the last time you said or did something like this?

SITBI27 Please give your best estimate for the following questions.

How many times in the past week have you hurt yourself to lead someone to believe that you wanted to kill yourself when you really had no intention of dying?
How many times in the past month have you hurt yourself to lead someone to believe that you wanted to kill yourself when you really had no intention of dying?
How many times in the past year have you hurt yourself to lead someone to believe that you wanted to kill yourself when you really had no intention of dying?
How many times in your life have you hurt yourself to lead someone to believe that you wanted to kill yourself when you really had no intention of dying?

SITBI28 Regarding times that you have hurt yourself to purposely lead someone to believe you wanted to kill yourself when you really had no intention of dying: On average, how much did you want to die when you did something like this on a scale from 0-4?

SITBI29 Have you ever been very close to killing yourself and at the last minute, you decided not to before you took any action (e.g., held a bottle of pills in your hand but decided not to take any, set up a noose but decided not to use it, pointed a gun to your head)?

- No
- Yes

SITBI30 Please give your best estimate for the following questions.

How many times in the past week have you been very close to killing yourself and at the last minute, you decided not to before you took any action?

How many times in the past month have you been very close to killing yourself and at the last minute, you decided not to before you took any action?

How many times in the past year have you been very close to killing yourself and at the last minute, you decided not to before you took any action?

How many times in your life have you been very close to killing yourself and at the last minute, you decided not to before you took any action?

SITBI31 Have you ever been very close to killing yourself and at the last minute, someone or something else stopped you before you took any action (e.g., held a bottle of pills in your hand, but then someone walked in and stopped you before you took any pills, pointed a gun to your head but then someone came in and stopped you)?

- No
- Yes

SITBI32 Please give your best estimate for the following questions.

How many times in the past week have you been very close to killing yourself and at the last minute, someone or something else stopped you before you took any action?

How many times in the past month have you been very close to killing yourself and at the last minute, someone or something else stopped you before you took any action?

How many times in the past year have you been very close to killing yourself and at the last minute, someone or something else stopped you before you took any action?

How many times in your life have you been very close to killing yourself and at the last minute, someone or something else stopped you before you took any action?

SITBI33 Have you ever tried to kill yourself? In other words, have you ever purposely hurt yourself with some intent to die? We are including any of the following events: Times where you started to try to kill yourself but then stopped yourself after you had taken some action (e.g., took one pill of an overdose but then decided not to continue). Times where you started to try to kill yourself, but then someone or something else stopped you after you had taken some action (e.g., took one pill of an overdose but then someone walked in and stopped you from continuing). Times where you tried kill yourself and then called for help after. Times where you tried to kill yourself and then no one found you.

- No
- Yes

SITBI34

How old were you the first time?
How old were you the last time?

SITBI35 Please give your best estimate for the following questions.

In the past week, how many suicide attempts have you made?
In the past month, how many suicide attempts have you made?
In the past year, how many suicide attempts have you made?
In your lifetime, how many suicide attempts have you made?

SITBI36 The following questions refer to the suicide attempt that caused the most physical harm and/or in which you had the strongest desire to die.

SITBI37 What method did you use?

- overdose
- cutting
- auto exhaust
- other gases
- poison
- firearms
- hanging
- suffocation
- stepping in front of a train/car
- crashing a car
- jumping from a height
- drowning
- other _____

SITBI38 If you selected "overdose," please select each type of drug you used the most recent time you tried to kill yourself. If you did not select overdose, do not check any of the boxes below.

- own prescription drug
- someone else's prescription drug
- over the counter medication
- illicit drug
- alcohol

SITBI39 If you took an overdose, what substance(s) did you take? Please list each substance you took and the approximate amount (e.g., "Abilify: 60 mg"). If you did not take an overdose, type NA.

SITBI40 Please select which of the following best describe(s) your injuries:

- No damage
- Conscious-some respiratory distress but no resuscitation needed

- Conscious-minimal to moderate efforts at resuscitation needed
- Conscious-extensive effort at resuscitation needed
- Unconscious-massive efforts at resuscitation necessary for revival
- Unknown

SITBI41 Please select which of the following best describe(s) your injuries:

- Minor bruises only - no treatment necessary
- Sprains or minor injuries - no bone, ligament, or tendon damage; no internal bleeding, tissue or brain damage
- Extremities fractured - casting necessary but no major tendon repair and complete recovery expected
- Major bone and/or tendon damage in multiple areas - internal bleeding; some residual impairment expected but not in vital areas
- Major damage to vital area (skull, neck, spinal column) - paralysis expected
- Unknown

SITBI42 Please select which of the following that describe(s) your injuries:

- No damage
- Flesh wounds with powder burns
- Bullets lodged in extremity - minor bleeding
- Bullet in abdomen or chest - major bleeding; vital signs unstable
- Bullet to head area
- Unknown

SITBI43 Please select which of the following best describe(s) your injuries:

- No damage
- Simple rope burns
- More extensive injuries with treatment on outpatient basis
- Hospitalization and resuscitation required
- Paralysis or other spinal cord injury
- Unknown

SITBI44 Please select which of the following best describe(s) your injuries:

- Surface scratches; none or minor bleeding; little or no wound care required
- Moderate bleeding with clotting before significant blood loss occurs; simple wound care required
- Bleeding of major vessel, danger of considerable blood loss without surgical intervention- suturing necessary but no transfusion; vital areas intact and no change in vital signs; care on outpatient basis
- Extensive blood loss; suturing, blood replacement and tendon repair required; wound may be to head, chest, or abdomen but vital organs intact and vital signs stable; recovery with inpatient care expected

- Extensive blood loss with shock; injury to vital areas with change in vital signs
- Unknown

SITBI45 Please select each of the following that best describe(s) your injuries:

- No injuries
- Minimal medical consequences or treatment
- Conscious but sleepy
- Some injury (e.g. mouth burns) and treatment in emergency room or on out-patient basis (e.g. having your stomach pumped)
- Injuries sufficient for hospitalization - vital signs and level of consciousness were affected
- Major injuries including puncturing of digestive organ(s) (e.g., colon); kidney failure; blood hemolysis; shock; or unstable vital signs
- Lethargic- speech and mobility slowed but responsive to questions; intellectual functions intact
- Lethargic with decreased intellectual ability
- Severely blunted, dull, or lacking in vigor, but awake and somewhat responsive
- Asleep but easily aroused
- Unconscious but reflexes intact/responsive to pain
- Unconscious - no reaction to painful stimuli with most reflexes still intact; pulse and breathing are normal
- Unconscious - most reflexes absent; pulse and breathing are normal
- Unconscious - all reflexes absent; slowed breathing with discolored skin or circulatory failure and shock

SITBI46 From 0 to 4, how much did you want to die when you tried to kill yourself during your most serious attempt?

SITBI47 From 0 to 4, how confident were you that using your chosen method would result in death?

SITBI48 Thinking of all the times you have tried to kill yourself, what methods did you use (please select each method you have used)?

- overdose
- cutting
- auto exhaust
- other gases
- poison
- firearms
- hanging
- suffocation
- stepping in front of a train/car
- crashing a car

- jumping from a height
- drowning
- other _____

SITBI49 On average, how long have you usually thought about suicide before trying to kill yourself?

- 0 seconds
- 1-59 seconds
- 1-15 minutes
- 16-60 minutes
- Less than one day
- 1-2 days
- 3-6 days
- 1-2 weeks
- 2+ weeks
- Wide range (spans > 2 responses) _____

SITBI50 On a scale of 0 to 4, regarding all of the time(s) you have tried to kill yourself, on average, how much did you want to die?

SITBI51 On a scale of 0 to 4, regarding all of the time(s) you have tried to kill yourself, on average, how much did you think that the method you chose would result in death?

SITBI52 Has anyone you have ever known died by suicide? If so, how many people?

- No
- Yes (please enter #) _____

SITBI53 What was/were their relationship(s) to you?

- mother
- father
- brother
- sister
- daughter
- son
- biological aunt
- biological uncle
- grandmother
- grandfather
- cousin
- partner/lover
- personal friend
- family friend

- acquaintance
- other relative _____

SITBI54 Has anyone you have ever known attempted suicide but lived? If so, how many people?

- No
- Yes (please enter #) _____

SITBI55 What was/were their relationship(s) to you?

- mother
- father
- brother
- sister
- daughter
- son
- biological aunt
- biological uncle
- grandmother
- grandfather
- cousin
- partner/lover
- personal friend
- family friend
- acquaintance
- other relative _____

Suicide Intent Scale (SIS)

Complete only if you have ever made a suicide attempt in your lifetime. Carefully read each group of statements below. Please indicate the statement in each group that **best** describes how you were feeling when you made your **most recent suicide attempt**. Be sure to read all of the statements in each group before making a choice.

SIS1 1. Was anyone around when you tried to make yourself die?

- 0. Somebody was right by me / in the same room.
- 1. Somebody was able to see or hear me.
- 2. No one was around.

SIS2 2. Did anyone stop you from making yourself die? Could they have?

- 0. Yes, I timed it so that someone would be around to stop me.
- 1. I timed it so that someone might be around; or I didn't even think about it.
- 2. No, no one could have stopped me.

SIS3 3. Did you try to hide or make sure that no one knew you were trying to kill yourself?

- 0. No, I didn't try to hide.
- 1. I stayed away from others, but didn't try and keep them from me (for example: alone in a room, door unlocked)
- 2. Yes, I made sure no one could find me (for example: locking doors)

SIS4 4. Did you try to get someone to help you during or after trying to make yourself die?

- 0. Yes, I told someone what I did and asked for help.
- 1. I called someone, but didn't tell them exactly what I did.
- 2. No, not at all.

SIS5 5. Did you do anything to get your things in order / prepare for death, or say goodbye to anyone?

- 0. No.
- 1. I thought about giving things away / saying goodbye to someone.
- 2. Yes, I gave things away / said my goodbyes.

SIS6 6. Did you write a suicide note?

- 0. No, I didn't write one.
- 1. I thought about it; or started writing one but didn't finish / tore it up.
- 2. Yes, I wrote a note.

SIS7 7. Did you tell anyone that you were going to kill yourself before you tried?

- 0. Yes, I told someone I was going to kill myself.
- 1. I told someone I was thinking about it; or I gave other people clues that I might try.
- 2. No, I didn't tell anyone-it was a secret.

SIS8 8. Which of the following best matches the reason you tried to kill yourself?

- 0. To make others angry; to get someone's attention; or to get back at someone.
- 1. Combination of "0" and "2".
- 2. To escape from my situation or to solve problems.

SIS9 9. How did you feel about wanting to die?

- 0. I wanted to keep on living.
- 1. I wasn't sure if I wanted to live or die.
- 2. I was sure that I wanted to die.

SIS10 10. Did you think that what you did was enough so that you would actually die?

- 0. No, I did less to myself than what I thought would kill me.
- 1. I wasn't sure if it would kill me.
- 2. Yes, I thought for sure that I would die.

SIS11 11. How serious were you about wanting to die?

- 0. I didn't really want to die.
- 1. I wasn't sure if I really wanted to die.
- 2. I was serious about wanting to die.

SIS12 12. Did you think that a doctor could help you stay alive after you tried to kill yourself?

- 0. I thought that if I saw a doctor I wouldn't die.
- 1. I wasn't sure if a doctor could help me.
- 2. I was sure I would die, even if a doctor helped me.

SIS13 13. How much did you plan / think about your attempt to kill yourself before you tried?

- 0. Not at all.
- 1. For 3 hours or less before I tried.
- 2. For more than 3 hours.

SIS14 14. Have you ever tried to kill yourself before this time?

- 0. No, I have never tried.
- 1. Yes, I have tried before.