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Research paper

Are suicidal thoughts reinforcing? A preliminary real-time monitoring study on the potential affect regulation function of suicidal thinking

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ABSTRACT

Background: Theoretical work and clinical observation suggest that many patients experience relief from negative affect after thinking about suicide, which may increase the likelihood of future suicidal thoughts. Accordingly, our objective was to examine whether the occurrence of suicidal thinking was followed by decreased negative affect and increased positive affect.

Methods: Participants were 43 adults who attempted suicide at least once in the past year (78% female, 78% White, *M* age = 23.28 years, *SD* age = 4.38 years) who completed 28 days of smartphone-based real-time monitoring, where they were signaled four times/day to report on current affect and whether they were having suicidal thoughts. Participants could initiate a survey whenever they had a suicidal thought.

Results: First, we examined changes in affect that occurred when suicidal thinking at the current time (T) but not at T + 1 (approximately 4–8 h later). Negative affect decreased and positive affect increased when participants went from a period when they were experiencing suicidal thoughts to a period where they were not. Second, to assess the time course of changes in affect, we examined changes in affect before and after participant-initiated reports of suicidal thinking. Positive affect increased and sadness decreased.

Limitations: Given its preliminary nature, the study has some limitations including insufficient power to expand beyond a 4–8 h timespan.

Conclusions: Findings provide preliminary evidence that suicidal thinking leads to shifts in affect. These shifts in affect may be reinforcing, helping to explain (in part) why suicidal thinking is so persistent for some patients.

1. Introduction

Theoretical work and clinical observation suggest that many patients experience relief after thinking about suicide, which they perceive as comforting or as providing an escape from their seemingly intolerable circumstances (Gordon et al., 2010; O'Connor, 2003; Selby et al., 2007). This might mean that recurrent suicidal thinking is maintained because it leads to downward shifts in negative affect (i.e., negative reinforcement by providing an escape) or upward shifts in positive affect (i.e., positive reinforcement by providing comfort). Two prior studies that asked people who had suicidal thoughts in the past to recall how they felt when having suicidal thoughts reported that people recall feeling distressed when thinking about suicide, but some people also report comfort in the context of suicidal thinking (Crane et al., 2014, 2012). These earlier findings are intriguing, but are limited by a reliance on long-term retrospective recall and a failure to repeatedly assess changes in affective states from before to after the occurrence of suicidal thinking.

Smartphone-based ecological momentary assessment (EMA) approaches now allow for the collection of data about changes in affective states as they occur throughout the day (Kleiman and Nock, 2018; Shiffman et al., 2008). EMA studies on non-suicidal self-injury (NSSI) have shown, for instance, that engagement in NSSI is associated with decreases in negative affective and increases in positive affect, which seem to reinforce this behavior (Ammerman et al., 2017; Nock et al., 2009). No prior studies have examined whether thinking about suicide may be associated with similar affective changes. Here we used real-time, smartphone-based assessments to capture shifts in affect in situ. We expected to find that episodes of suicidal thinking are associated with subsequent decreases in negative affect and increases in positive affect.

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2. Method

2.1. Participants/recruitment

Inclusion criteria for this Harvard University IRB-approved study were: (1) a suicide attempt in the past year, (2) age 18 +, (3) ability to read English fluently, and (4) access to a compatible Android or iPhone smartphone. We recruited from a variety of suicide-related online message boards on Reddit (www.reddit.com). A total of 854 people completed the screener for the study, 103 of whom qualified (744 out of the 751 who did not qualify for the study had not attempted suicide in the past year and the remaining seven who did not qualify were either under 18 years old, could not read English fluently, and/or did not own a compatible smartphone). Of the 103 who qualified, 54 completed the study and represented the full sample described elsewhere (Kleiman et al., 2017). Data for our analyses are from 43 of those 54 individuals. Eleven of the 54 participants were excluded because they did not have any reports of suicidal thinking followed by a report where there was not suicidal thinking (i.e., the main criterion for our primary analysis, which is described later). Compared to the participants that were not included, those who were included had significantly more responses ($t = 10.14$, $p < 0.001$), reflecting a higher response rate among those who were included (63.2% vs. 58.9%, $\chi^2 = 4.09$, $p = 0.043$). There were no significant differences between those who were and were not included on age ($t = 0.07$, $p = 0.491$), race ($\chi^2 < 0.001$, $p = 0.99$), or gender ($\chi^2 = 0.35$, $p = 0.56$).

2.2. Procedure

After completing a screener to determine eligibility, participants were given an online consent form to review and electronically sign. Participants then completed a brief set of baseline self-report measures (that were not used in any of the analyses in this paper), then began a 28-day real-time monitoring period in which they were prompted four times per day via a smartphone app (MobileEMA; ilumivu.com). Prompts were sent randomly within pre-specified windows of time to not interfere with sleeping. At each prompt, participants were asked to report on their current mood and whether or not they were having suicidal thoughts. If participants skipped an item on the real-time monitoring survey, they were prompted to complete it, which contributed to no missing data on these surveys.

2.3. Measures

2.3.1. Affect

We measured a variety of affective states derived from the Positive and Negative Affect Schedule (Watson and Clark, 1994), supplemented with some suicide-specific items. Specifically, we assessed eight negative affect states (afraid, agitated, angry, anxious, burdensome, hopeless, lonely, sad) and three positive affect states (active, happy, and optimistic) on a 0 (not at all) to 4 (very much) scale. In addition to the individual affect states, we also created composite scores for average momentary negative and positive affect. Reliability for these scales calculated according to standard conventions for repeated-measures data using a null model (Nezlek, 2017) was acceptable ($\alpha = 0.92, 0.78$ for negative and positive affect, respectively).

2.3.2. Suicidal thinking

We measured suicidal thinking using an average of three items assessed on a 0 (not strong) to 4 (very strong) scale: one's desire to die by suicide, one's intent to die by suicide, and one's ability to resist the urge to die by suicide (reverse coded). As described below, for the purposes of this study, we dichotomized this score (0 and > 0). Participants could also self-initiate an assessment whenever they had a suicidal thought or engaged in non-suicidal self-injury (e.g., cutting self on purpose). This assessment was used to indicate when a suicidal thought or non-suicidal self-injurious behavior occurred.

2.4. Analytic strategy

We conducted two sets of analyses to test the hypothesis that the occurrence of suicidal ideation is associated with decreases in negative affect and increases in positive affect. In the first analysis, we selected pairs of consecutive responses that occurred within the same day where participants indicated suicidal ideation at time T (i.e., any score > 0 on the suicidal ideation composite) and no suicidal ideation at time T + 1 (i.e., any score that equaled 0 on the suicidal ideation composite). We then conducted a series of three-level multilevel models (response pairs within events within people) where time of response (i.e., during suicidal thinking [T] vs. after suicidal thinking [T + 1]) was specified as a level 1 variable and time between responses was specified as a level 2 variable (because assessments were random and thus the time between them varied). We analyzed a separate model for each affective state as well as overall negative affect and positive affect summary scores specified as the dependent variable. The results of these analyses could be interpreted as change in affect from T (during suicidal thinking) to T + 1 (after suicidal thinking). Thus, a positive regression coefficient would indicate an increase in affect from T to T + 1, whereas a negative regression coefficient would indicate a decrease in affect from T to T + 1.

This first analysis did not allow us to conclusively determine the time course of changes in affect relative to instances of suicidal thinking because suicidal thinking and affect were assessed simultaneously. Thus, in a second analysis we selected instances of participant-initiated reports of suicidal thinking and examined changes in affect states from the assessments that occurred *before* and *after* each instance within the same day. In all analyses, variables were centered on participant means, meaning that a score of 0 meant the average score on that variable for that participant. All multi-level models used fixed slopes because models with random slopes did not improve model fit or change the interpretation of the results. All analyses were conducted in R, using the following packages: *EMAtools* (Kleiman, 2017) to structure and center the data, *lme4* (Bates et al., 2015) to analyze the data, and *ggplot2* (Wickham, 2009) to make the figures.

3. Results

3.1. Preliminary analyses

The sample was 78% female, 73% White, and had a mean age of 23.28 years (*SD* age = 4.38 years). There were 305 pairs of responses occurring during the same day where participants reported suicidal thinking at T but not at T + 1 ($M = 7.09$ pairs of responses per participant, $SD = 5.23$, range 1–20), out of a total of 540 pairs of responses. The average time between these pairs of responses was 7.95 h ($SD = 5.35$). There were 37 participant-initiated reports of suicidal thinking by 14 participants ($M = 2.64$ pairs of responses per participant, $SD = 3.76$, range 1–6). The average time between pre- and post-event responses was 10.54 h ($SD = 8.27$; average time between pre-event rating to event and event to post-event rating was 2.48 h, $SD = 3.55$). The 14 participants who self-initiated a report of suicidal thinking and completed momentary assessments of suicidal thinking did not differ on momentary ratings of suicidal thinking from the 29 participants who only reported suicidal thinking on the momentary assessments ($B = 0.16$, $p = 0.531$).

3.2. Changes in affect following suicidal thinking

As hypothesized, instances of suicidal thinking were followed by decreases in negative affect and increases in positive affect, with each affective state showing significant changes in the expected direction (Table 1). As can be seen in Fig. 1, these changes do not appear to be

Table 1
Changes in affect following suicidal thinking.

	Descriptive statistics		Multi-level model		
	***M* T**	***M* T + 1**	***B***	**95% *CI***	***p***
Negative Affect Composite	0.28	− 0.28	**− 0.55**	**− 0.65 to − 0.45**	**< 0.001**
Afraid	0.19	− 0.24	**− 0.42**	**− 0.57 to − 0.27**	**< 0.001**
Agitated	0.32	− 0.31	**− 0.62**	**− 0.79 to − 0.45**	**< 0.001**
Angry	0.31	− 0.37	**− 0.68**	**− 0.83 to − 0.52**	**< 0.001**
Anxious	0.14	− 0.18	**− 0.32**	**− 0.48 to − 0.16**	**< 0.001**
Burdensome	0.32	− 0.27	**− 0.57**	**− 0.75 to − 0.40**	**< 0.001**
Hopeless	0.38	− 0.30	**− 0.66**	**− 0.82 to − 0.50**	**< 0.001**
Lonely	0.27	− 0.24	**− 0.49**	**− 0.68 to − 0.31**	**< 0.001**
Sad	0.33	− 0.34	**− 0.65**	**− 0.80 to − 0.50**	**< 0.001**
Positive Affect Composite	− 0.18	0.23	**0.40**	**0.29 to 0.50**	**< 0.001**
Active	− 0.07	0.17	**0.24**	**0.09 to 0.38**	**0.010**
Happy	− 0.24	0.25	**0.49**	**0.35 to 0.62**	**< 0.001**
Optimistic	− 0.22	0.26	**0.46**	**0.32 to 0.61**	**< 0.001**

Note. Multi-level model results control for time between assessments, which was not significant in any model (*p*s ranged from 0.09 to 0.95) and thus not reported for clarity reasons. *B* can be interpreted as slope from T to T + 1.

due to regression to the mean, as for each affective state assessed, the values do not revert back to zero (the mean-centered value), but instead change to the opposite side of the scale. More specifically, average negative affect scores change from a range of 0.14 to 0.38 at T to a range of − 0.37 to − 0.18 at T + 1. Similarly, positive affect scores change from a range of − 0.22 to − 0.07 at T to a range of 0.17 to 0.26 at T + 1.

3.3. Changes in affect from before to after suicidal thinking

In more conservative analyses that examined changes in affect from before-to-after suicidal thinking that occurred in the interim, the occurrence of suicidal thinking was associated with significant decreases in feeling "sad" and increases in overall positive affect as well as in the more specific item "active" (Table 2; Fig. 2). There were no other significant changes in affect from pre- to post-episode. To rule out the possibility that the observed changes were due to engagement in NSSI, we examined whether any of the suicidal thinking co-occurred with NSSI. There were only three such instances, and removing these three cases from this analysis did not change the results.

4. Discussion

The goal of this study was to explore where the occurrence of

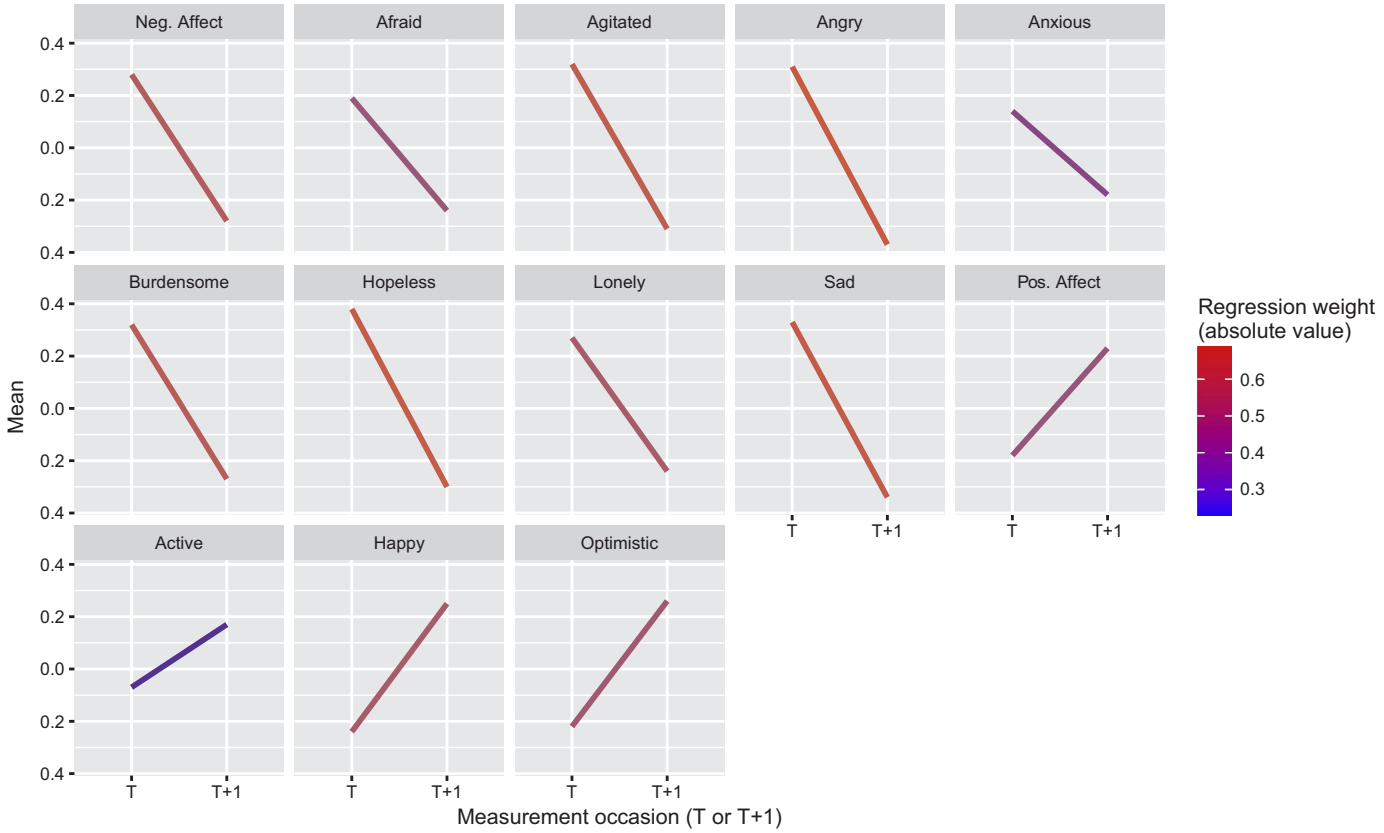

Fig. 1. Changes in affect following suicidal thoughts. Note: Weights are from multi-level models, adjusting for time between T and T + 1. All $p < 0.05$. All variables are person-mean centered (i.e., 0 = each participant's individual mean on that variable).

Table 2
Descriptive statistics and multi-level model results predicting pre- to post-participant-initiated episode changes in affect.

	Descriptive statistics		Multi-level model		
	***M* pre**	***M* post**	***B***	**95% *CI***	***p***
Negative Affect Composite	0.17	− 0.18	− 0.36	− 2.44 to 1.72	0.74
Afraid	0.16	0.42	0.28	− 0.01 to 0.57	0.06
Agitated	0.26	0.47	0.23	− 0.27 to 0.72	0.38
Angry	0.44	0.50	0.06	− 0.43 to 0.54	0.82
Anxious	0.27	0.28	0.01	− 0.32 to 0.33	0.97
Burdensome	0.33	0.42	0.08	− 0.29 to 0.46	0.66
Hopeless	0.55	0.48	− 0.08	− 0.42 to 0.25	0.63
Lonely	0.39	0.02	− 0.38	− 0.80 to 0.03	0.07
Sad	0.69	0.18	**− 0.53**	**− 0.93 to − 0.14**	**0.01**
Positive Affect Composite	− 0.37	0.40	**0.77**	**0.09 to 1.44**	**0.03**
Active	− 0.31	0.10	**0.43**	**0.09 to 0.76**	**0.01**
Happy	− 0.31	− 0.17	0.16	− 0.10 to 0.42	0.23
Optimistic	− 0.34	− 0.17	0.18	− 0.11 to 0.47	0.23

Note. Multi-level model results control for time between assessments, which was not significant in any model (*p*s ranged from 0.38 to 0.94) and thus not reported for clarity reasons. *B* can be interpreted as slope from pre- to post-episode of suicidal thinking.

suicidal ideation lead to downward shifts in negative affect and upward shifts in positive affect. There were two main findings that provide preliminary evidence for this hypothesis. First, we found decreases in negative affect (and its component parts) and increases in positive affect (and its component parts) when participants went from a period when they were experiencing suicidal thoughts to a period where they were no longer experiencing suicidal thoughts. Second, several of these changes remained when conducting more conservative analyses in which affect changed from before-to-after episodes of suicidal thinking. Taken together, these findings support clinical observation about the potentially reinforcing nature of suicidal thoughts, are in line with cross-sectional work in this area (Crane et al., 2014, 2012), and may help to explain the persistence of suicidal thinking in some patients.

Notable strengths of this study include the use of a clinically-relevant sample and assessment of affect in the moment, which was not done in prior studies exploring the reinforcing nature of suicidal thinking. The primary limitation is the relatively small sample size, especially for the analyses examining participant-initiated reports of ideation. Given this small sample size, this study should be considered preliminary and in need of replication. The sample's generalizability is also a limitation. Participants were relatively young adults who engaged in online discussion about suicide. Thus, it is unknown if these findings would generalize to older adults and to those who avoid discussing suicide.

These findings are preliminary, especially given that there was not complete replication across the two sets of analyses. Thus, further research is needed before we can discern actionable clinical implications. However, there are several specific lines of research that would serve to build on these findings to make them more clinically useful. First, this study provides the first evidence suggesting that suicidal thinking might be reinforcing because having suicidal thoughts led to decreased negative affect (i.e., negative reinforcement) and increased positive affect (i.e., positive reinforcement). If suicidal thoughts are indeed reinforcing, however, future studies should examine whether those who experience greater reduction in negative affect and greater increases in positive affect actually go on to have more suicidal thoughts in the future. Second, future studies should more carefully track when episodes of suicidal thinking "start" and "stop" so the time course of these effects can be more carefully documented. Third, it is likely that suicidal thinking is not reinforcing for all people at all times. In line with

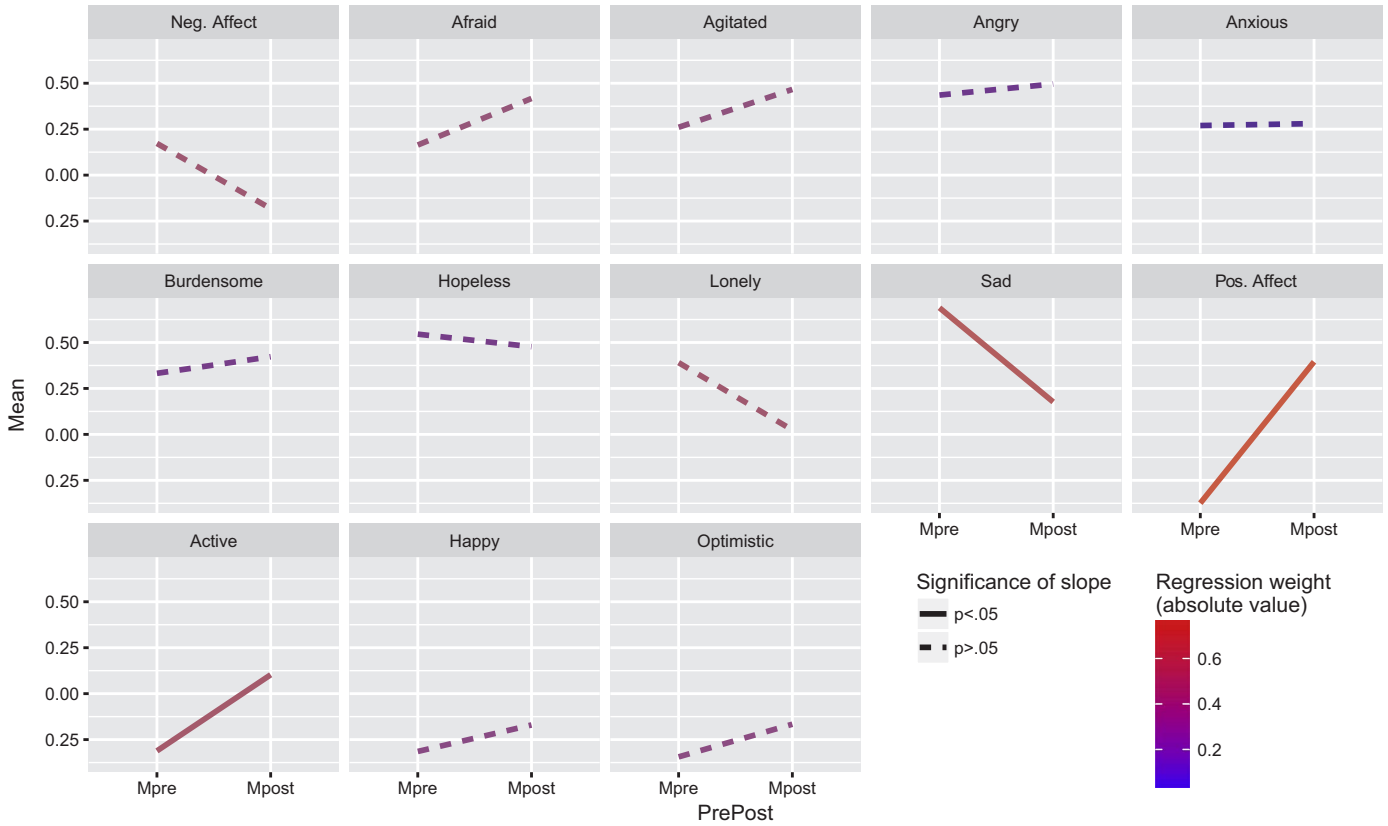

Fig. 2. Changes in affect from pre- to post-participant-initiated episodes of suicidal thinking. Note: Weights are from multi-level models, adjusting for time between Pre- and post-event. All $p < 0.05$. All variables are person-mean centered (i.e., 0 = each participant's individual mean on that variable).

this idea, nearly 75% of suicidal individuals in one study reported feeling comfort from having suicidal thoughts to at least some extent, but only approximately 15% of the sample implied that they experienced comfort regularly (Crane et al., 2014). Accordingly, exploring potential moderators of these effects in a larger sample of patients over a longer period of time is an important next step in determining for whom and at what times suicidal thinking is reinforcing. Finally, there may be processes at play other than reinforcement that occur in the time between when suicidal thinking begins and negative affect decreases or positive affect increases. For example, people may be engaging in behaviors to cope with their suicidal thinking (e.g., reaching out to others) that could also lead to changes in affect. Examining coping behaviors may also help identify when and for whom suicidal thinking is reinforcing. Relatedly, research on diurnal variation in mood (Clark et al., 1989; Peeters et al., 2006) suggests that changes in suicidal thinking could be a result of natural fluctuations in mood. Taken together, this might mean that increases in negative affect and decreases in positive affect drive increases in suicidal thinking and as negative affect subsides and positive affect increases (through coping or own their own), suicidal thinking also subsides. Thus, future efforts should more carefully and comprehensively track other cognitive, affective, and behavioral phenomena that occur before, during, and after episodes of suicidal thinking – methods possible with recent advances in smartphone and biosensor technologies (Kleiman and Nock, 2018, 2017).

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