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Suicide and Life-Threatening BEHAVIOR

ORIGINAL ARTICLE

Fluidity in capability: Longitudinal assessments of suicide capability using ecological momentary assessments

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Abstract

Introduction: Suicide capability is posited to facilitate the movement from ideation-to-action. Emerging evidence suggests capability comprises both trait- and state-like facets. This study examined fluctuations in and associations of acquired, dispositional, practical, and perceived capabilities, and suicidal mental imagery, and suicidal ideation.

Method: Seventy-five adults (48 females, *M*age = 36.53 years) with lived experience of suicidal ideation and/or attempt responded to four prompts per day for 2 weeks that assessed suicide capability and suicidal ideation. Mean-squared successive differences and probability of acute change indices and multilevel models were used for analyses.

Results: All facets of suicide capability fluctuated. Acquired and dispositional capabilities were trait-like, with practical and perceived capabilities being state-like. Suicidal mental imagery was the only facet of suicide capability that distinguished participants with a suicide attempt in the past 12 months from participants with a suicide attempt more than 1 year ago and suicide ideators. Suicidal mental imagery was associated with concurrent suicidal ideation and predictive of next assessment suicidal ideation.

Conclusion: Suicidal mental imagery may be uniquely associated with suicide capability. This study suggests there are trait- and state-like facets of capability that can combine to potentially ready an individual to engage in suicidal behaviors.

KEYWORDS

ecological momentary assessment, integrated motivational-volitional model, interpersonal theory of suicide, suicidal ideation, suicide, suicide capability, three-step theory of suicide

INTRODUCTION

Experiencing suicidal ideation does not always progress to attempting and/or dying by suicide. Suicide capability is the theoretical mechanism that enables an individual to act on suicidal ideation (see Interpersonal Theory of Suicide [ITS], Joiner, 2005; Van Orden et al., 2010; Integrated Motivational-Volitional [IMV], O'Connor, 2011; O'Connor & Kirtley, 2018; Three-Step Theory of Suicide [3ST], Klonsky & May, 2015; Klonsky et al., 2021). According to the ITS, an individual develops and retains an acquired capability for suicide from repeated exposure to painful and provocative events (e.g., child abuse) that enables the individual to attempt suicide because of a reduced fearlessness about death and a greater pain tolerance. The IMV acknowledges that acquired capability is a volitional factor but also includes additional factors to provide further understanding of the movement from ideation-to-action. For example, suicidal mental imagery was found to differentiate individuals with a history of suicidal ideation from individuals who had attempted suicide (De Rozario et al., 2021; Wetherall et al., 2018). However, a criticism of these models is that they consider the facets of suicide capability in isolation rather than in combination. For example, the ITS proposes that the single factor of acquired capability is "sufficient to cause" the movement from ideation-to-action (Millner et al., 2020, p. 3), and the IMV focuses on isolated variables (Brüdern et al., 2022). Thus, additional models are needed to understand how these facets interact with one another (Keefner & Stenvig, 2020).

The 3ST (Klonsky et al., 2021; Klonsky & May, 2015) is one such model as it considers suicide capability as a multifaceted construct comprising acquired, dispositional, and practical capabilities. Acquired capability (Joiner, 2005) is maintained by the 3ST, while dispositional capability pertains to genetic and personality aspects. However, the 3ST differs from the ITS in that pain tolerance is considered a dispositional contributor due to its genetic associations (Nickerson et al., 2022; Shahnaz et al., 2020; Trost et al., 2015). Practical capability is conceptualized as accessibility and knowledge of lethal means. It is the interplay of these capabilities that comprise overall capability (Khazem & Anestis, 2016; Klonsky et al., 2021). This acknowledgment of multiple and intersecting contributing factors of capability reflects the complexity and countless pathways to a suicide attempt (Tandon, 2021). The definition that "total suicide capability" (Klonsky et al., 2021, p. 2) reaches a level sufficient for an individual to act on suicidal ideation, and the conceptualization of capability from this model forms the foundation of this study.

Not only has there been a movement toward considering multiple contributing factors (Bayliss et al. 2021), Smith and Cukrowicz (2010) propose that capability also has both long- and short-term facets, with short-term facets contributing to acute momentary increases in overall capability. If capability fluctuates and comprises both trait- and state-like facets, then this may mean that increases in capability combined with suicidal ideation positions the individual at an imminent risk of attempting suicide. Despite the above, most capability research continues to focus on single risk factors using cross-sectional research designs (Bayliss et al., 2022; May & Victor, 2018). As such, there is little research that has looked at potential fluctuations in capability, which has restricted our temporal understanding of capability. In order to investigate the fluid nature of capability, longitudinal research is first needed to identify whether capability includes both trait- and state-like facets.

Few studies have longitudinally examined suicide capability and those that have been conducted have produced somewhat differing results. Fearlessness about death has been found to be quite stable over an eight-week period (Velkoff & Smith, 2019) with both fearlessness about death and pain tolerance being stable over 2 years (Bryan et al., 2016). Yet, Schuler et al. (2021) reported weekly fluctuations in acquired capability as a combination of fearlessness about death and pain tolerance during a 90-day study with capability returning to baseline levels over 90 days. Furthermore, Zuromski et al. (2018) collected data every 3 days over a 15-day period and found that a critical aspect of acquired capability, fearlessness about death, slightly increased and decreased (e.g., group means range 347.68–364.56 [out of maximum 700]). These findings raise questions about acquired capability being a static construct as first conceptualized. The authors of these studies themselves question the "acquired" nature of capability and suggest capability includes trait-like facets given the reported fluctuations and return to baseline levels. Notably, these studies only included acquired capability and therefore overlooked other facets of suicide capability that may be more dynamic/state-like such as practical capability. Capturing potential state-like fluctuations in suicide capability requires studies and designs capable of collecting intensive longitudinal data.

Ecological momentary assessment (EMA; Shiffman et al., 2008) is such a design that is increasingly being used for real-time occurrences of suicidal thinking but remains relatively underutilized in suicide capability research (Ammerman & Law, 2022; Davidson et al., 2017; Kivelä et al., 2022; Kleiman et al., 2023). A study design such as EMA enables data to be collected longitudinally through repeated assessments about suicidal thoughts and/or behaviors on smart devices outside the laboratory as participants live their lives in the real world (Ballard et al., 2021). As such, EMA increases the ecological validity of study findings as it is not constrained

by single, retrospective assessments, thus allowing for short-term fluctuations to be detected (Myin-Germeys et al., 2018). Furthermore, hindsight bias (i.e., recollections tend to be more accurate when presented with the correct information [Kaida & Kaida, 2023]) may be reduced using EMA because of the recency of data collection, potentially improving data validity (Wrzus & Neubauer, 2023). However, EMA, particularly when used in suicide research, is not without limitations. For example, the time before a suicide attempt is characterized by distress and agitation and not conducive to study participation, self-report is still a limitation despite the reduction of hindsight bias, there is a lack of psychometric measures developed to assess suicidal ideation and suicide capability with EMA studies, and potential missing data during a suicidal crisis (Ballard et al., 2021; Kleiman et al., 2019; Wrzus & Neubauer, 2023). Nonetheless, EMA provides an opportunity to capture fluctuations in suicide capability that are not easily captured using other research methods.

Little research has sought to explicitly explore fluidity in capability. Two EMA studies investigating suicide capability included additional facets of capability beyond acquired capability. Spangenberg et al. (2019) added perceived capability (i.e., perception that one could kill themselves [Rimkeviciene et al., 2016]) to acquired capability and collected data once a day (i.e., 8:00 p.m.) for six days. They found reported acquired capability and perceived capability fluctuated in approximately 90% and 75% of participants. Recently, temporal stability and associations between facets of capability and suicidal intent were examined six times a day over 14 days (Rogers et al., 2022). Both acquired (i.e., fearlessness about death) and practical capability (i.e., physical and psychological distance to suicide method) were found to fluctuate. These findings are important as they indicate these facets of capability can be temporally unstable. Both studies suggest additional research is needed to identify short-term components of capability. This suggestion and recommendations to expand beyond acquired capability and study acute changes in capability have been echoed in recent reviews on intensive longitudinal studies for suicide research (Ammerman & Law, 2022; Kivelä et al., 2022). The potential benefit of capturing acute changes in capability and/or novel constructs that have been found to differentiate suicide ideators from suicide attempters (i.e., suicidal mental imagery; De Rozario et al., 2021; Wetherall et al., 2018) is in advancing the nature and time-course conceptualisation of capability.

Suicide research has tended to focus on verbal suicidal thoughts rather than suicidal mental imagery (Lawrence et al., 2022). However, an emerging body of literature reports imagery is more prevalent than verbal suicidal thoughts (Lawrence et al., 2023; Millner et al., 2023) and has a higher likelihood of being associated with a history of suicide attempt(s) than verbal suicidal thoughts (Lawrence et al., 2021; Lawrence, Nesi, & Schwartz-Mette, 2022; Lawrence et al., 2022; Lawrence et al., 2023). In addition to findings that imagery can differentiate suicide attempters from suicide ideators (De Rozario et al., 2021; Wetherall et al., 2018), imagery can be dynamic (Zaleskiewicz et al., 2023) and episodic (Lawrence et al., 2023) and therefore appropriate for EMA studies. Furthermore, suicidal cognitions, such as mental imagery, are not currently considered as part of suicide capability despite a recent review reporting cognitive differences between suicide attempters and ideators (Bayliss et al., 2022). Given the above, imagery warrants further investigation within suicide-focused EMA studies.

Thus, this study aims were twofold. First, we examined short-term fluctuations of suicide capability as a multifaceted concept including acquired, dispositional, practical, and perceived capabilities, and added suicidal mental imagery. The addition of suicidal mental imagery is in response to the novel finding of Wetherall et al. (2018) that is reflective of the IMV (O'Connor, 2011; O'Connor & Kirtley, 2018). Based on recent findings (Rogers et al., 2022; Spangenberg et al., 2019), we expected facets of capability to fluctuate. Second, we examined facets of suicide capability occurring concurrently with and predictive of suicidal ideation. Although capability is assumed to be of particular importance to suicide attempts, "no research has examined the mechanisms of onset and offset of suicidal thoughts during momentary assessments" (Millner et al., 2023, p.23). Therefore, we conducted exploratory analyses to gain insight into the potential of capability as a mechanism of suicidal thoughts. Given this was an exploratory aim, no a priori hypotheses have been presented.

METHOD

Participants

A total of 157 individuals were recruited between May 2022 and August 2022. Electronic recruitment flyers were posted on author and Roses in the Ocean's (a lived experience suicide organization) social media accounts, and we advertised the study on Reddit that geographically targeted Australian users. Inclusion criteria was self-identified lived/living experience of suicidal ideation and/or suicide attempt(s). Of the 157 respondents who completed an online consent form, 21 (13%) did not respond

to a follow-up invitation email, 32 (20%) did not download the app or downloaded but did not start the EMA protocol, and 19 (12%) disengaged from the study for a variety of reasons (e.g., deleted the app). This resulted in 85 participants completing the EMA study. However, 10 (6%) of these participants responded to less than 40% of the prompts and were not included in the sample for analysis. Included and excluded (i.e., those who completed less than 40% of EMA prompts) participants were compared on sample characteristics using Kruskal–Wallis tests. There were no significant differences with regard to age, gender, location, suicidal ideation, suicide attempt history, or any of the suicide capability variables at baseline. The final sample was 75 participants.

Given the lack of consensus about agreed power for multilevel modeling, we followed sample size recommendations based on Monte Carlo simulations for two-level models, which indicated that medium effect sizes could be detected with level 2 sample sizes up to 200 participants (Arend & Schäfer, 2019). Thus, a post hoc power analysis indicated this sample size was considered sufficiently powered (i.e., ≥0.80 with a significance criterion of 0.05) to detect medium effect sizes (Arend & Schäfer, 2019).

The 75 participants were an adult Australian community-based sample (64.0% female, 24.0% male, and 12.0% other), aged 19–76 years ($M = 36.53$ years, SD = 10.79), located primarily in a metropolitan area (65.3%). Fifty participants (66.7%) reported at least one suicide attempt. Of these participants, nine participants reported a suicide attempt one-year prior, 13 participants reported a suicide attempt between 1 and 5 years prior, and 28 participants reported a suicide attempt 5–10 years prior. All participants provided electronic informed consent, which included their hours of availability for completing assessments. Each participant was provided with an AUD $20.00 e-gift card. To incentive a higher compliance rate, participants who achieved a compliance rate of 80.00% or greater were eligible to enter a prize draw valued at $1000 worth of gift cards. The study was approved by the Human Research Ethics Committee of the University of Southern Queensland (H21REA239).

EMA protocol

Participants were prompted at random times to complete four daily assessments for 14 consecutive days using the SEMA3: Smartphone Ecological Momentary Assessment mobile application (Koval et al., 2019). A minimum of 6 h of daily availability required to complete the four assessments, and each participant nominated their availability. Assessments needed to be completed within 30 min of receiving the notification, and subsequent assessments were scheduled not to occur within 30 min of another assessment.

Suicide capability was measured multidimensionally using the single items displayed in Table 1. Single item measures are considered valid and recommended for short, repeated assessments in EMA study designs (Hughes et al., 2019; Nock et al., 2009; Victor & Klonsky, 2014). The items were phrased "in the past 15 min" to increase coverage and capture recent activities whilst avoiding retrospective reporting as per the coverage model of EMA (Shiffman et al., 2008; Stone et al., 2023). For example, if imagery was only captured in the exact moment of the assessment, there is a chance it may not have been reported compared to "in the past 15 min." Item order was randomized for each assessment with items being rated on a 5-point scale from "0 = do not agree at all" to "4 = completely agree."

Suicidal ideation was assessed binarily using "*I want to die by suicide*," which is phrased like an item measuring active suicidal ideation by Forkmann et al. (2018). During the study, 42 participants responded "yes" to "*I want to die by suicide*" resulting in a total of 138 occurrences (individual range 1–13 occurrences). This item conditionally branched to safety protocol items as suggested by Glenn et al. (2020). All risk/safety monitoring items are presented in Appendix 1. If participants answered 3 or greater to risk monitoring item 2 ("*How able are you to keep yourself safe right now*?") or answered yes to item 3 ("*Did you do anything to hurt yourself today*?"), then a welfare call ($n = 16$) was conducted. Five participants reported self-harm without intent to die and no

TABLE 1 Suicide Capability Items Used in Assessments.

Facet of capability	EMA item	Reference
Acquired	In the last 15 min "I have not been afraid of death"	Shahnaz et al., 2020, p.1237
Dispositional	In the last 15 min "I could handle pain more easily than other peoplen"	Shahnaz et al., 2020, p.1237
Practical	In the last 15 min "I could access the method/means I would use to kill myself"	Shahnaz et al., 2020, p.1237
Perceived	In the last 15 min "I could have killed myself if I wanted to (even if you have never wanted to kill yourself, please answer this question)"	Rimkeviciene et al., 2016, p.961
Suicidal mental imagery	In the last 15 min "I have had mental images of myself planning/preparing to harm myself or make a suicide attempt"	Wetherall et al., 2018, p.478

participant reported a suicide attempt. At the end of each risk/safety assessment participants were provided with details for a support service within the mobile application.

Data analysis

To quantify variability and temporal (in) stability, intraclass correlations (ICCs), mean squared successive differences (MSSDs), and probability of acute change (PAC) were used. The ICCs indicate the proportion of variance due to mean differences between persons (Eisele et al., 2022). An ICC of 1.0 indicates all variability is between-person and an ICC of 0 indicates nil between-person variability (i.e., all variability is within-person; Bolger & Laurenceau, 2013). The MSSD (von Neumann et al., 1941) represents any change between two consecutive assessments regardless of direction (i.e., increasing or decreasing) or size of change (Jahng et al., 2008). It provides an average measure of variance with larger values indicating greater variability (Egbert et al., 2022). In addition to the MSSD average variance, acute increases of change (i.e., 1-,2-, and 3-point changes similar to Jacobucci et al., 2022) using the PAC index (Jahng et al., 2008) were examined. The PAC indicates the probability of an acute increase from one assessment to the next. Intraclass correlations were extracted from unconditional multilevel models, and MSSDs and PACs were calculated using formulas presented in Appendix 2.

The EMA dataset has a multilevel structure (up to 56 observations nested within each of 75 individuals) resulting in 4200 assessment signals with 3067 (73.02%) valid observations. Multilevel models were used given their ability to handle missing and nested data and thus are suitable for analyzing EMA data (Schwartz & Stone, 1998). Data analysis for multilevel models was iterative. Two sets of models were conducted in R using the packages *lme4* (Bates et al., 2015) and *lmerTest* (Kuznetsova et al., 2017), with *effectsize* (Ben-Shachar et al., 2020) used for Cohen's *f, broom. mixed* (Bolker & Robinson, 2019) used for odds ratios, and *ggplot2* for graphs (Wickham, 2016).

The first set of models contained individual suicide capability items as the outcome, with predictors being suicide history that was coded as suicide ideator, suicide attempt between 5 and 10 years prior, 1–5 years prior, and suicide attempt within 1-year prior, and time-lagged capability items (Bolger & Laurenceau, 2013; Hughes et al., 2019). Night-time lagged suicide capability variables were removed from analyses (i.e., first assessment of each day starting from the second day of participation) to reduce variability. Three iterative models with individual suicide capability items as the outcome were tested (i.e., three models for each of the five items). The first model was an unconditional model to determine that multilevel modeling was appropriate for the dataset. The second model added time as a predictor to check for nonlinear trajectories; time was not significant. The final model added the predictors.[1]

The second set of models included suicidal ideation (i.e., "*I want to die by suicide*") as the outcome with suicide capability items as predictors. Two multilevel logistic regression models were used to examine (1) suicide capability items concurrent with suicidal ideation; and (2) suicide capability items predicting next assessment suicidal ideation. Predictors were (lagged) person-mean-centred (i.e., level one predictors) to disaggregate from the between-person (i.e., level two predictors) effects that were group-mean centred (Wang & Maxwell, 2015). Thus, within-person effect is the time-specific deviation of that predictor from its person-specific mean, and the between-person effect is how much each participant's average score differs from the mean for the entire sample. Furthermore, we controlled for the auto-regressive effect of suicidal ideation by adding a lagged suicidal ideation variable as a predictor. Predictor variables used random intercept and fixed slopes as participants had different starting values.[2] While we acknowledge the potential of inflated Type I error that may occur with multiple comparisons, we did not include adjustments for multiple comparisons but instead described the tests conducted given the exploratory nature of analyses as per Gosliner et al., 2022; Gupta et al., 2022; Monteith et al., 2023; Perneger, 1998; Rothman, 1990.

RESULTS

Overall compliance with the EMA protocol was good (*M* [SD] = 74.5% [0.2]; range 40.0%–100%). The average time between prompts was 2:54:00 (SD = 01:13:12, range 0:31:12–5:57:00). Descriptive and variability statistics for facets of suicide capability are shown in Table 2. On average, acquired and practical capabilities showed similar mean levels that were higher than the similar mean levels of dispositional and perceived capabilities, all of which were substantially higher than the low mean for suicidal mental imagery. These differences are descriptive.

Does suicide capability fluctuate?

As expected, all facets of suicide capability fluctuated. Examination of ICCs indicated that approximately 30% of

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TABLE 2 Descriptive and Variability Statistics for Facets of Suicide Capability in the Last 15 min.

Suicide capability item	Mean (range)	SD	ICC	Mean MSSD (range)[a]	Mean PAC1 (range)[b]	Mean PAC2 (range)[c]	Mean PAC3 (range)
Acquired – In the last 15 min I have not been afraid of death	2.46 (0–4)	1.42	0.69	0.94 (0–4.48)	0.17 (0–0.40)	0.06 (0–0.28)	0.02 (0–0.13)
Dispositional – In the last 15 min I could handle pain more easily than other people	1.95 (0–4)	1.32	0.71	0.84 (0–5.79)	0.19 (0–0.53)	0.05 (0–0.21)	0.02 (0–0.21)
Practical – In the last 15 min I could access the method/means I would use to kill myself	2.22 (0–4)	1.63	0.55	2.02 (0–7.82)	0.18 (0–0.46)	0.09 (0–0.34)	0.06 (0–0.29)
Perceived – In the last 15 min I could have killed myself if I wanted to	1.96 (0–4)	1.58	0.50	2.04 (0–8.11)	0.20 (0–0.46)	0.10 (0–0.44)	0.06 (0–0.44)
Imagery – In the last 15 min I have had mental images of myself planning/preparing to harm myself or make a suicide attempt	0.43 (0–4)	0.91	0.28	0.80 (0–6.22)	0.12 (0–0.44)	0.05 (0–0.33)	0.02 (0–0.26)

[a]The mean MSSD for acquired and dispositional capabilities are less than fearlessness about death (1.99; range 0–12.80) and pain tolerance (1.21; range 0–7.5) reported by Spangenberg et al. (2019). However, the perceived capability mean (but not maximum) MSSD is greater than the Spangenberg et al. MSSD for perceived capability (1.37; range 0–13.67).

[b]Mean PAC1 for acquired, dispositional, practical, and perceived capabilities were similar to thwarted belongingness (0.18) and perceived burdensomeness (0.17) reported by Jacobucci et al. (2022).

[c]Mean PAC2 for practical and perceived capabilities were greater than thwarted belongingness (0.07) and perceived burdensomeness (0.05) reported by Jacobucci et al. but similar to acquired and dispositional capabilities.

acquired and dispositional variance was associated with within-person variances, which was less than practical (45%) and perceived capabilities (50%) within-person variances. This indicates that practical and perceived capabilities were more unstable and state-like than acquired and dispositional capabilities that were more stable and trait-like. Suicidal mental imagery had the greatest amount of within-person variability at 72%, suggesting a state-like construct.

Participants' temporal (in) stability for all facets of suicide capability differed widely. Some participants had temporal stability (i.e., MSSD value of 0) whilst other participants were less stable (e.g., MSSD value of 8.11). On average, practical and perceived capabilities showed similar and the greatest MSSD values, indicating the largest temporal instability of all items. Acquired and dispositional capabilities and suicidal mental imagery displayed, on average, similar MSSD values. However, MSSD only represents any score change, regardless of the size of change.

Degree of changes in scores is thus better reflected by the PAC. The PAC provides the degree of change from one time-point to the next (e.g., a PAC with a cut-off of 1 is moving from t to $t+1$). On average, acquired, dispositional, practical, and perceived capability had similar PACs (1), and all were greater than suicidal mental imagery. Practical and perceived capability had greater PACs of 2 and 3 (i.e., moving from t to $t+2$, t to $t+3$), on average, compared with acquired, dispositional, and suicidal mental imagery. This indicates that on average, acute changes in facets of suicide capability were greatest for practical and perceived capabilities. Like MSSD values however, some participants reported larger PACs than others. The largest individual participant PACs (2 and 3) for suicidal mental imagery was similar to practical capability and greater than acquired and dispositional capabilities. This suggests that there are changes in suicidal mental imagery that are more acute than acquired and dispositional capabilities.

Are facets of suicide capability related to history of suicidal ideation and/or attempt?

Results of multilevel regression analyses with suicide capability items as the outcomes are presented in Tables S1–S5. When examining effects related to history of suicidal ideation or suicide attempts, only suicidal mental imagery was significant. On average, participants with a prior suicide attempt within one-year tended to report higher levels of suicidal mental imagery than participants who attempted suicide more than one-year prior and participants without a suicide attempt. The effect sizes were medium (Cohen, 1992; Lorah, 2018).

TABLE 3 Results of Multilevel Logistic Regression Models: Concurrent and Prospective Associations Between Active Suicidal Ideation and Facets of Suicide Capability.

		Concurrent suicidal ideation					Prospective suicidal ideation	
Random effects		**Variance**				**Variance**		
Intercept		1.57				0.59		
Fixed effects	***B***	**SE**	***p***	**OR (95% CI)**	***B***	**SE**	***p***	**OR (95% CI)**
(Intercept)	−4.70	0.28	**<0.001**		−3.92	0.21	**<0.001**	
Suicidal ideation auto-regressive effect					1.47	0.38	**<0.001**	4.36 (2.05, 9.26)
Within-person								
Estimates								
Acquired	0.25	0.16	0.11	1.29 (0.95, 1.75)	0.20	0.16	0.22	1.22 (0.89, 1.68)
Dispositional	−0.20	0.15	0.19	0.82 (0.61, 1.10)	−0.07	0.16	0.71	0.93 (0.68, 1.26)
Practical	−0.20	0.13	0.14	0.82 (0.63, 1.07)	−0.08	0.13	0.42	0.92 (0.71, 1.19)
Perceived	0.25	0.13	0.06	1.28 (0.99, 1.65)	0.11	0.13	0.24	1.11 (0.87, 1.44)
Imagery	1.64	0.12	**<0.001**	5.15 (4.04, 6.57)	0.32	0.18	**0.01**	1.38 (1.08, 1.77)
Between-person								
Estimates								
Acquired	0.01	0.22	0.96	1.01 (0.66, 1.55)	0.24	0.18	0.20	1.27 (0.89, 1.80)
Dispositional	−0.33	0.22	0.14	0.72 (0.47, 1.12)	−0.24	0.19	0.20	0.78 (0.55, 1.13)
Practical	−0.32	0.28	0.25	0.73 (0.42, 1.26)	−0.15	0.21	0.48	0.86 (0.57, 1.31)
Perceived	0.36	0.32	0.25	1.44 (0.78, 2.68)	0.17	0.25	0.47	1.19 (0.73, 1.93)
Imagery	0.78	0.43	0.07	2.18 (0.94, 5.03)	1.03	0.32	**0.001**	2.81 (1.49, 5.32)
Model indices								
Participants	75				75			
Observations	3056				2239			
Deviance	676				616			

Note: bold indicates significant values at the $p < 0.05$ level.

Are within-person facets of suicide capability associated with and/or predictive of suicidal ideation?

Results of multilevel logistic regression analyses are displayed in Table 3. Suicidal mental imagery was significantly associated with concurrent suicidal ideation at the within-person level with the effect size being medium (Chen et al., 2010). Furthermore, suicidal mental imagery at both the within- and between-person levels significantly predicted next assessment suicidal ideation, with effect sizes again being medium (Chen et al., 2010).

No effects were found for acquired, dispositional, practical, and perceived capabilities.

What facets of suicide capability increased prior to and when self-harm was reported?

Suicidal behaviors are not typically included in results given the low rates at which they occur within studies (Rogers et al., 2022) because of the issue of generalisability (Fisher et al., 2018). Whilst understandable, its exclusion perhaps overlooks data that can potentially contribute to meaningfully to theoretical progress. Therefore, facets of suicide capability for five participants that reported self-harm have been included in Figures 1–5. Looking across capability facets, all four participants were either already at the highest capability item score or indicated an increased in capability for acquired and practical capability, and suicidal mental imagery in the assessment prior to reporting self-harm.

DISCUSSION

The first hypothesis that facets of suicide capability would fluctuate was supported. However, the exploratory aims regarding suicide capability associations with suicidal ideation produced few significant findings.

Findings indicate that there was considerable variability for facets of suicide capability. Acquired, dispositional, and perceived capability within-person variances were greater than from previous studies (Rogers et al., 2022;

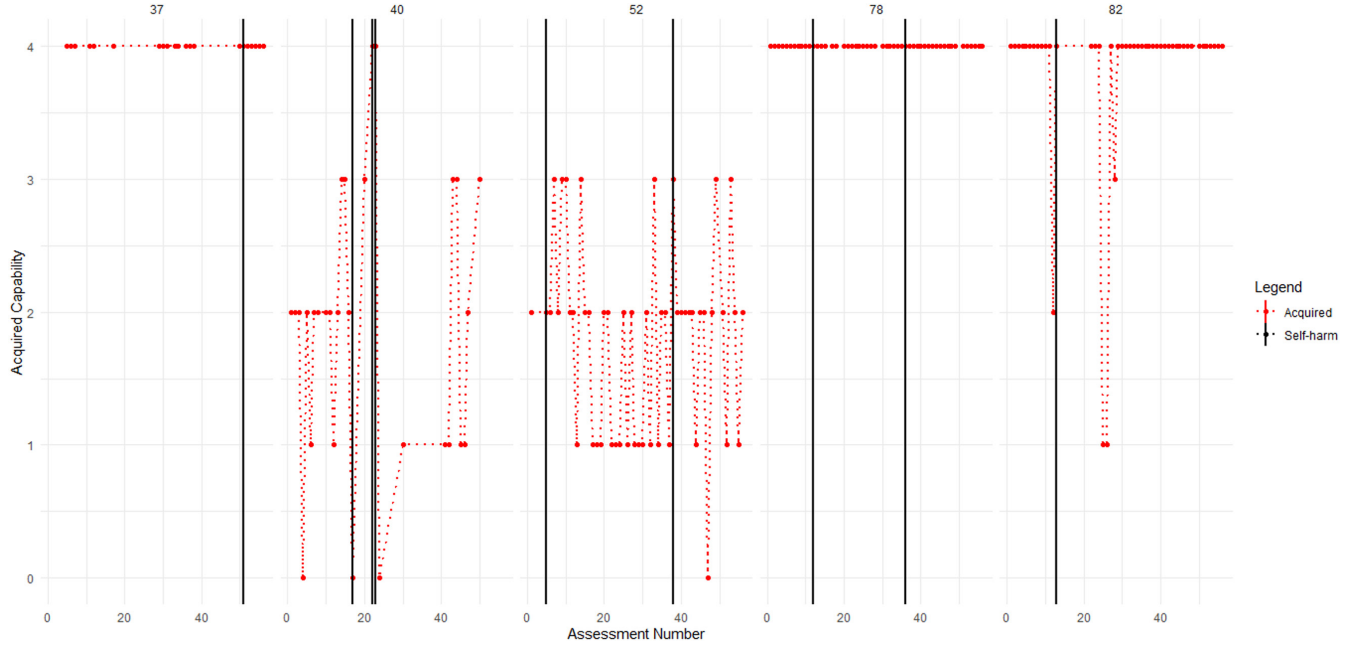

FIGURE 1 Acquired Capability Fluctuations for Participants That Reported Self-Harm.

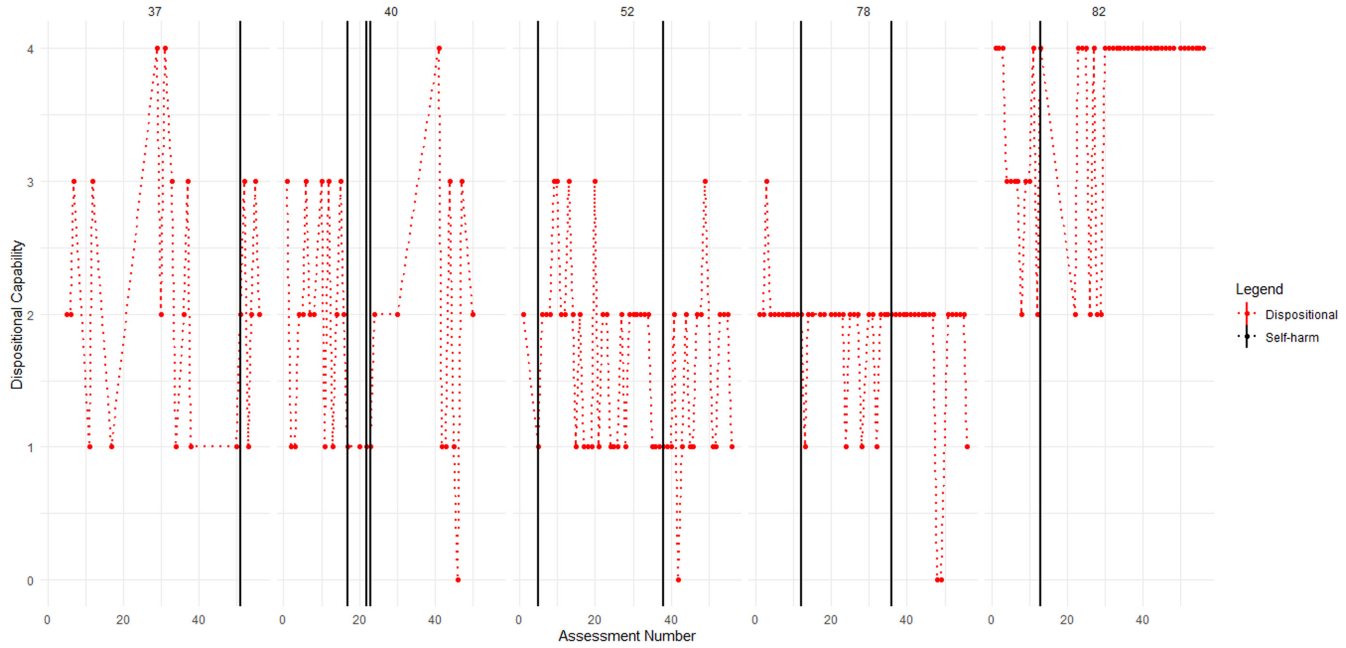

FIGURE 2 Dispositional Capability Fluctuations for Participants That Reported Self-Harm.

Spangenberg et al., 2019). Differences may be related to previous studies including participants with a greater risk of suicide than this study. Further, Spangenberg et al. assessed capability daily at a fixed time (i.e., 8:00 p.m.) and Rogers et al. assessed six times a day. These differences in distances between adjacent prompts may have also contributed to the different results across studies. Nevertheless, our findings are consistent with emerging evidence that capability is less stable than initially conceptualized.

Suicidal mental imagery

Suicidal mental imagery produced unique results compared with other facets of capability. Assessment to assessment fluctuations of imagery were less than acquired and dispositional capabilities. This may be reflective of the low MSSD mean because the maximum MSSD was greater than both acquired and dispositional capabilities. However, PAC2 and 3 values for imagery were similar to practical capability thus

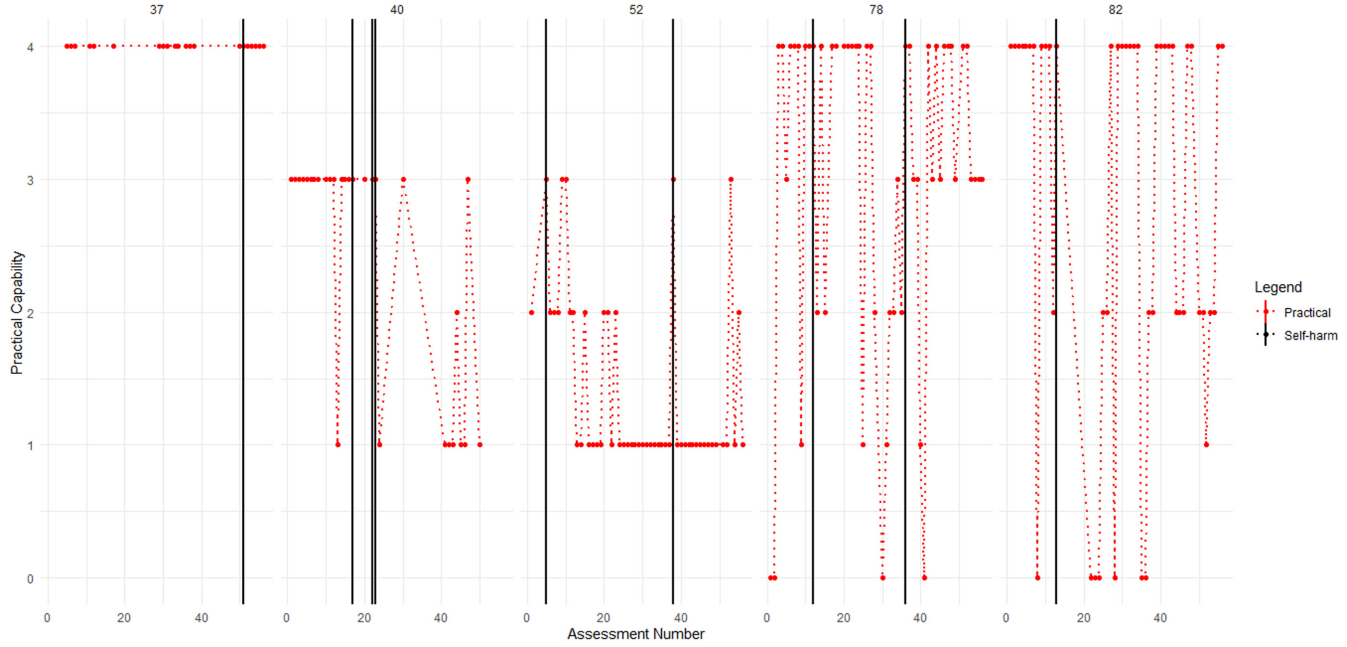

FIGURE 3 Practical Capability Fluctuations for Participants That Reported Self-Harm.

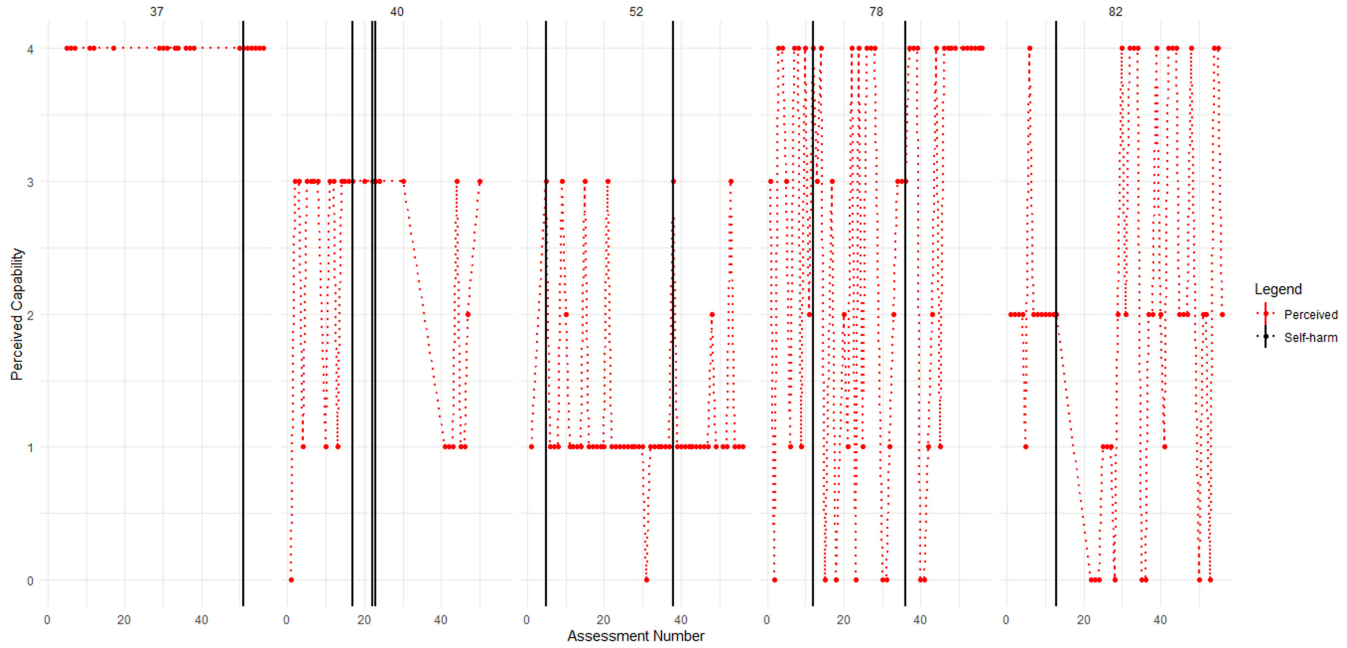

FIGURE 4 Perceived Capability Fluctuations for Participants That Reported Self-Harm.

appearing state-like. Further, the data suggests imagery reduces significantly one-year plus postsuicide attempt. This reduction in mental imagery is not unique to suicide as the visual saliency of images has been found to diminish over time (Cooper et al., 2019). Therefore, these novel findings provide an initial starting point for further consideration that imagery may be a state-like component of capability.

The results also provide preliminary evidence that on one hand, suicidal mental imagery could be uniquely associated with suicide capability. It distinguished recent suicide attempters from less-recent suicide attempters and suicide ideators, whilst also occurring during and being predictive of suicidal ideation. On the other hand, imagery may be a correlate of capability. The repeated exposure to imagery could increase acquired capability given the habituation hypothesis that underpins the fearlessness about death construct (Lawrence et al., 2023), which speaks to the combination of capabilities. Again, because

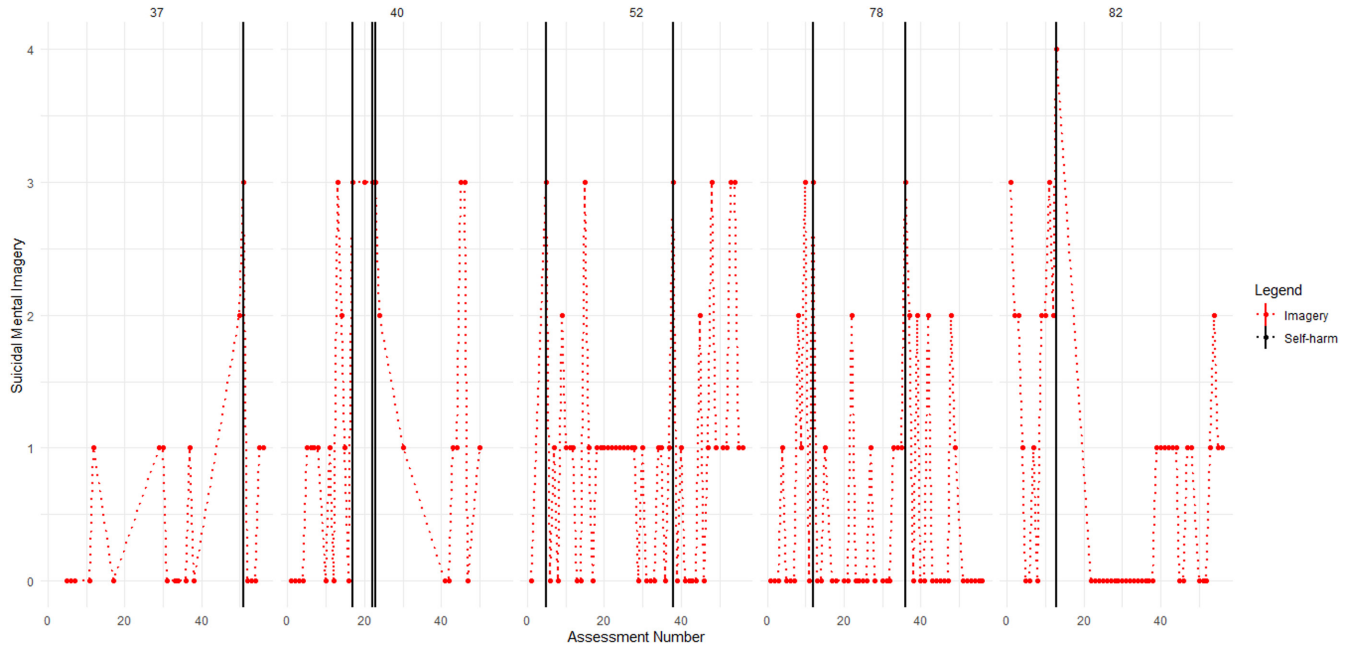

FIGURE 5 Suicidal Mental Imagery Fluctuations for Participants That Reported Self-Harm.

is the first study to explore imagery in combination with other facets of capability using EMA, it is a starting point that warrants further consideration.

Taken together, the suicidal mental imagery findings from this study provide tentative empirical support for a cognitive facet of suicide capability as suggested by Bayliss et al. (2022). Furthermore, these findings are in accordance with recent research focusing on adolescents that found suicidal mental imagery differentiated ideators and attempters (De Rozario et al., 2021). According to Lawrence, Nesi, Burke, et al. (2021); Lawrence, Nesi, and Schwartz-Mette (2022), suicidal cognitions are typically considered to be verbal suicidal thoughts, yet adolescents who reported suicidal mental imagery were more than twice as likely to have attempted suicide after controlling for verbal suicidal thoughts. This suggests that while verbal suicidal thoughts may also contribute to suicide capability, suicidal mental imagery appears to contribute to a greater degree. This may be because of greater intensity and realism associated with images compared to verbal thoughts (Lawrence et al., 2022). As the two Lawrence et al. studies were cross-sectional, the current study adds to the limited suicidal mental imagery literature and does so using a longitudinal study.

Theoretical implications

The current results have potential significant implications for theoretical models of suicide within the ideation-to-action framework that go beyond the potential of suicidal mental imagery as a unique component of suicide capability. The absence of facets of capability distinguishing suicide attempters and suicide ideators is contradictory to current theories. It is possible that the discrepant findings are related to the limitations of verbal models of suicide that lack thorough description of suicidal thoughts (Millner et al., 2023). Another possible explanation for this finding is that capability for suicide as it is currently conceptualized is insufficient for understanding the movement from ideation-to-action within a community sample. This may be due to the large proportion of knowledge about capability being derived from clinical, serving and veteran military personnel, and incarcerated individuals (Bayliss et al., 2022). For community populations, it may be more accurate to conceptualize capability to just-prior-to-action as the suicidal individual moves into a suicide readiness state as suggested by Capron et al. (2022). That is, a state that includes the combination of suicidal ideation and elevated capability as the data indicated in this study.

Perhaps the participants that reported self-harm from this study can help toward an initial characterization of the suicide readiness state. The data suggest that already elevated and/or increases in acquired, practical, and perceived capabilities, and suicidal mental imagery may indicate an individual could be in a suicide readiness state. This finding highlights the potential usefulness of clarifying the suicide readiness state for when just-in-time interventions should potentially be delivered to keep people safe. Further, the reporting of low base rate behaviors such as suicide attempts may help to further clarify this state given it is challenging to do so without such reporting.

Limitations and future directions

This study has numerous strengths, such as the large proportion of suicide attempters in the sample, frequency of assessments, and the inclusion of practical capability and suicidal mental imagery. However, there are limitations given the exploratory nature of the study. First, the lack of assessments such as suicide risk and other variables may have introduced uncontrolled confounding variables. One example being substance use frequency, which has been found to be related to capability (Baer et al., 2022). However, this study was designed to assess capability, not all aspects of suicidality. Therefore, psychiatric disorders were not assessed given psychopathology is more likely to contribute to suicidal ideation rather than capability (Alqueza et al., 2023; May & Klonsky, 2016). Furthermore, suicide risk assessment was not conducted because we did not want to exclude participants based on suicide risk (Armey et al., 2020; Nock et al., 2021). Second, participants were aware that if they reported risk then a welfare call would occur. This may have led to under-reporting of suicidal ideation and/or attempts because participants may have wanted to avoid contact with the research team (Bai et al., 2021). Additionally, we acknowledge that understanding reasons for non-responses in EMA studies is important as they can be associated with mental symptom burden and/or suicide risk (Kivelä et al., 2022). However, despite our efforts to contact participants and understand their reasons for dropping out of this study, we did not receive replies and therefore it is not appropriate to speculate on reasons for non-responses in this study. Third, whilst single-item measures are appropriate for EMA studies they are limited when assessing psychological constructs because they may lack reliability (Rogers et al., 2022) and this may have contributed to the non-significant findings between suicide ideators and suicide attempters. Fourth, the wording of the suicidal mental imagery item is potentially problematic as it asks about both NSSI (i.e., "harm myself") and suicide attempt (i.e., "make a suicide attempt"). Although this item was sourced from Wetherall et al. (2018) and is characteristic of other studies exploring imagery (Lawrence et al., 2023), the inclusion of both self-harm and suicide attempt within the one question is a limitation in that it is unclear which aspect participants were responding to. Finally, the phrasing of "in the past 15 min" could have possibly introduced a degree of recall bias (Stone et al., 2023). Because of this potential limitation, it is important to consider these findings as exploratory.

Based on study findings, several recommendations for future research directions are offered. First, a greater sampling density (i.e., >4 daily assessments) over a longer period (>2-weeks) would provide greater insight about within-person changes that potentially unfold in shorter intervals. This would provide sufficient data for idiographic analyses to be conducted (Soyster et al., 2019) and explore indices of variability that may act trait-like and reflect diminished cognitive capacities (Brüdern et al., 2022). Second, it is recommended that future studies allow anonymous participation to reduce the tension introduced by welfare calls that can potentially lead to under-reporting of suicidal ideation and/or attempts (Bai et al., 2021). Further, given that conducting suicide-related EMA research is feasible and acceptable for individuals at high risk for suicide (Rogers, 2021). This may increase disclosure of suicidal behaviors and provide further understanding of the suicide readiness state (Capron et al., 2022). However, doing so introduces ethical challenges (e.g., risk and benefit) that need to be considered. Third, there is a critical need for reliable and valid measures of facets of capability for use in EMA studies given that interpretation of results may differ based on measures. The present study replicated perceived capability (Rimkeviciene et al., 2016) from the Spangenberg et al. (2019) study, drew upon the Suicide Capacity Scale (Klonsky & May, 2015), and followed Forkmann et al. (2018) suggestion for assessing suicidal ideation. However, the field would benefit from continuity of items as it allows results to be compared thus advancing the field through replicated incremental increases of knowledge (Bayliss et al., 2022). Finally, it is worth considering conducting research with participants with diurnal differences because of the increased risk during late evening and after midnight (Akkaya-Kalayci et al., 2017; Mansfield et al., 2022).

CONCLUSION

This study contributes to the emerging literature that suicide capability is not static as first conceptualized and contains both trait- and state-like facets as suggested by Smith and Cukrowicz (2010). Furthermore, contrary to current theoretical conceptualisations of capability, results suggest that clarification of what comprises capability warrants consideration. For example, the unique findings regarding suicidal mental imagery association with capability and suicidal ideation provides fertile ground for future research.

The role of capability as a facilitator in the movement from ideation-to-action requires elucidation. Currently, whether suicide capability and suicidal ideation equate to a suicide readiness state as suggested by Capron et al. (2022) is unclear. This study tentatively suggests that an individual may potentially be in a suicide readiness

state when the combination of acquired, practical, and perceived capabilities, and suicidal mental imagery are elevated. It is imperative that we start filling the knowledge gap that exists between the suicide readiness state and suicidal behaviors so that effective interventions can be developed for timely provision.

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CONFLICT OF INTEREST STATEMENT

The authors have declared no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available upon request from the corresponding author. These data are not publicly available due to privacy or ethical restrictions.

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ENDNOTES

[1] Comparison between the models in the paper and the time-added models was non-significant. Therefore, time was omitted from the models.

[2] Models failed to converge with random slopes and thus were not used.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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APPENDIX 1

Risk/Safety Assessment Items.

1. If yes to *"In the past 15 min have you thought "I want to die by suicide""*, then "*are you right now (or were you just) thinking of hurting yourself or attempting suicide*" ("yes" or "no"; adapted from Glenn et al., 2020).

2. If yes from previous question, "*How able are you to keep yourself safe right now?*" ("1 = I definitely can keep myself safe"; "5 = I definitely cannot keep myself safe") (Glenn et al., 2020, p. 7).

3. Continues from previous question, "*did you do anything to hurt yourself today?*" ("yes" or "no"; adapted from Glenn et al., 2020).

4. If yes from previous question, "*did you intend to die as a result of hurting yourself?*" (to determine suicide attempt as per Silverman et al., 2007).

APPENDIX 2

Functions used to calculate Mean Square of Successive Differences (MSSD) and Probability of Acute Change (PAC) in R (https://quantdev.ssri.psu.edu/sites/qdev/files/ILD_Ch02_2017_UnivariateIntraVar_Part2.html; N. Ram, personal communication, January 11, 2022).

MSSD

```
my.mssd <- function(data)
{
    diffToNext<-data[2:length(data)]-data[1:(length(data)-1)]
  #this computes the difference between each value and the next
    diffToNext2<-diffToNext^2
  #this squares the difference
    SSdiff<- sum(diffToNext2,na.rm=TRUE)
  #this takes the sum of the squared differences
    denominator<-sum(!is.na(diffToNext))
  #this computes the number of non-missing elements (denominator)
  #which corresponds to the t-1 value
    mssd<-SSdiff/denominator
  #this computes the MSSD
    return(mssd)
}
```

PAC

```
my.pac <- function(data, c)
{
    data.zoo <- zoo(data)
  #this converts to zoo object
    data.zoo.lag <- lag(data.zoo,-1,na.pad = TRUE)
  #this creates the lag variable
    ac = ifelse((data.zoo-data.zoo.lag) >= c,1,0)
  #this calculates the binary acute change
    denominator<-sum(!is.na(ac))
  #this computes the number of non-missing elements (denominator)
    pac <- sum(ac/denominator,na.rm=TRUE)
  #this calculates the pac
    return(pac)
}
```