



Variability in the Functions of Nonsuicidal Self-Injury: Evidence From Three Real-Time Monitoring Studies

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Despite functional models of nonsuicidal self-injury (NSSI) helping to explain why people engage in this perplexing behavior, we still lack an understanding of some of the key properties of NSSI functions. Here, we address three unanswered questions about NSSI functions: how much do distinct NSSI functions (1) vary between people over time, (2) vary within people over time, and (3) simultaneously co-occur over time? Data were drawn from three ecological momentary assessment (EMA) studies of self-injurious adult psychiatric outpatients ($n = 7$), community-based adolescents ($n = 15$), and community-based adults ($n = 9$). Across the three studies, there was a total of 271 NSSI episodes (all with corresponding functions captured by EMA). The vast majority (27 of 31; 87%) of participants exhibited unique patterns of NSSI functions during the monitoring periods, indicating high variability between people. The vast majority (26 of 31; 84%) of participants also showed changes in NSSI functions over time, indicating high variability within people. Although it was most common for only one function to be reported for a given NSSI episode, participants endorsed more than one function for 22% to 43% of NSSI episodes,

indicating that different functions did simultaneously co-occur. These results underscore that reinforcement processes for NSSI differ from person-to-person, and are both time-varying and multifaceted, which has implications for personalized assessment and treatment of this clinical phenomenon.

Keywords: nonsuicidal self-injury; ecological momentary assessment; functional analysis

EPIDEMIOLOGICAL STUDIES SUGGEST that 5% to 17% of people engage in nonsuicidal self-injury (NSSI) at some point in their lives (Nock, 2010; Swannell et al., 2014), with NSSI often persisting for several years before remission (Plener et al., 2015). The issue that has puzzled scholars for centuries (Favazza & Favazza, 1987) is *why* people engage in a behavior such as NSSI that goes against the innate drive for self-preservation (Nock, 2009)?

A functional approach proposes that behaviors are determined by their immediate antecedents and consequences (Nock, 2009). Nock and Prinstein's (2004) four-function model (FFM) proposes that NSSI is maintained through four reinforcement processes: automatic negative reinforcement (ANR), automatic positive reinforcement (APR), social negative reinforcement (SNR), and social positive reinforcement (SNR). ANR refers to engagement in a behavior to reduce

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or relieve aversive affective states, whereas APR refers to generating desired affective states. SNR refers to engagement in a behavior to escape aversive social event(s), whereas SPR refers to increasing desired social event(s) (e.g., help-seeking). The FFM has been validated in numerous samples (for reviews see: Bentley et al., 2014; Taylor et al., 2018), catalyzed new experimental paradigms (Hamza & Willoughby, 2015; Nock & Mendes, 2008), and contributed to the development of novel treatment approaches (Bentley et al., 2017). Although the FFM has provided a useful framework for understanding why people engage in NSSI, many key questions regarding the functions of NSSI remain unanswered (Bentley et al., 2014). One major limitation of prior research on NSSI functions is reliance on retrospective self-report, which are subject to recall biases (Schwarz, 2012).

Ecological momentary assessment (EMA), which refers to the repeated sampling of participants' experiences and behaviors in real time (Shiffman et al., 2008), offers a highly promising, novel methodological approach to studying the functions of NSSI as this behavior naturally unfolds. According to a recent systematic review, 35 studies have used EMA to study NSSI, but only 8 have used EMA to directly examine the FFM (Hepp et al., 2020). Both studies reported the overall prevalence of each FFM function in the entire sample across all EMA observations (with ANR as by far the most commonly reported function, ranging from being endorsed for 45% to 65% of all observed NSSI episodes across people), but did not examine how NSSI functions operate *within each person* over time. The current report seeks to improve upon and extend these studies by leveraging data from three EMA studies to address three largely unaddressed properties of the FFM: the *generalizability*, *stability*, and *co-occurrence* of NSSI functions.

HOW MUCH DO THE FUNCTIONS OF NSSI VARY BETWEEN PEOPLE OVER TIME?

Our first aim was to describe generalizability in the prevalence of the functions of NSSI over time. Prior meta-analytic research has established that these four functions occur across different self-injuring populations and that the ANR function is by far the most prevalent function across people (Taylor et al., 2018). What remains unclear, however, is generalizability from the group to the individual (Fisher et al., 2018). Basic descriptive work has demonstrated that a wide range of phenomena examined at the group level appear different when examined at the individual level (Hamaker, 2012).

For example, the structure of brain networks looks different when it is studied within-people as opposed to when it is estimated by averaging across people (Braga & Buckner, 2017). As this concept applies to NSSI functions, do all people who engage in NSSI have the same distributions of NSSI functions that is observed at the group level (e.g., ANR most frequent and SNR least frequent) or do different people show different distributions of functions? The intensive longitudinal nature of EMA may be an optimal method (at least of all currently available methods) to understand this foundational question about the functions of NSSI. Given that functions of NSSI are likely to inform effective, tailored treatment for this problematic behavior (Bentley et al., 2014; Hayes et al., 2018), it is crucial to understand if the prevalence of functions observed across individuals is generalizable to the individual patient.

HOW MUCH DO THE FUNCTIONS OF NSSI VARY WITHIN INDIVIDUALS OVER TIME?

Our second aim was to quantify the within-person variability in the functions of NSSI. There is currently little evidence regarding whether a person engages in NSSI for the same function each time they self-injure or if they alternate between a variety of different functions. We are aware of only one study to date that has examined longitudinal changes in the functions of NSSI (Victor et al., 2016). This study, which enrolled a sample of 537 patients, concluded that NSSI functions are generally stable across time. A limitation of the study, however, was that NSSI functions were only assessed twice and the duration of time between assessments varied drastically (mean = 137 days, standard deviation = 250 days). Furthermore, stability of NSSI functions was examined across the entire sample, but the researchers did not test individual differences in NSSI function stability. Thus, this study was not able to assess potentially meaningful changes in functions that occur over shorter (and thus more clinically useful) timeframes or at the individual level.

There has long been a call for psychologists to examine phenomena idiographically, at the level of the individual (Barlow & Nock, 2009; Hamaker, 2012). Recent advances in mobile technologies such as the smartphone have significantly facilitated such idiographic research (Piccirillo & Rodebaugh, 2019). One discovery from recent smartphone-based EMA studies on suicidal thoughts, which are closely linked with NSSI (Ribeiro et al., 2016), is that there is considerable within-person variability in patterns of suicidal thinking over time (Kleiman & Nock,

2018). The functions of NSSI, however, have not been examined with this type of within-person lens. Within-person variability in psychological constructs has been linked with a wide range of clinical outcomes (Fisher & Newman, 2016; Houben et al., 2015; Kleiman et al., 2018). Therefore, measuring variability in the functions of NSSI over time has the potential to both advance our understanding of how the FFM unfolds in daily life and potentially provide new, individualized treatment targets (Bentley et al., 2017).

HOW OFTEN DO THE FUNCTIONS OF NSSI CO-OCCUR OVER TIME?

Our third aim was to describe whether and how often the functions of NSSI co-occur within distinct NSSI episodes. The original FFM proposed that the different functions are significantly correlated (Nock & Prinstein, 2004) and there is evidence from cross-sectional surveys that people report having engaged in NSSI for multiple reasons (Andover et al., 2012; Taylor et al., 2018). What remains unclear from this line of research is whether NSSI serves multiple functions across distinct NSSI episodes or within a given NSSI episode. Better understanding the co-occurrence of functions could advance theoretical models of why individuals begin (and for some, continue) engaging in NSSI (e.g., Bentley et al., 2014; Nock & Prinstein, 2004). From a clinical perspective, quantifying the co-occurrence of functions may also help inform the selection or combination of intervention strategies targeting a particular function (e.g., emotion regulation strategies for ANR, interpersonal communication techniques for SPR) for individually tailored NSSI treatment.

THE PRESENT STUDY

Based on a lack of previous data, we did not generate specific hypotheses but instead aimed to explore these three questions about NSSI functions using data from three self-injuring samples: outpatients, community-based adolescents, and community-based adults. In each study, participants underwent an EMA protocol. We present novel data on the generalizability of NSSI function prevalence between people, stability of NSSI functions within people, and co-occurrence of NSSI functions in each of the three samples.

Methods

STUDY 1: OUTPATIENTS WITH NSSI DISORDER

Participants

The initial sample of participants were 10 adult outpatients who met criteria for NSSI disorder (including at least five days of NSSI in the past year). NSSI disorder criteria from DSM-5 were used for criteria (American Psychiatric Association, 2013). Other inclusion criteria were of at least 18 years of age, self-report of ANR as *at least one* of their reasons for engaging in NSSI (because the interventions tested in this study were most relevant for ANR), and stability of psychiatric medications. Data from a semistructured interview (ADIS-5; Brown & Barlow, 2014) was used in combination with clinical judgment to make determinations about study eligibility (Bentley et al., 2017).

Of the 10 participants, we excluded 3 participants who reported engaging in NSSI less than 3 times during the study because the analyses used in this paper required at least 3 data points to be able to examine within-person variability (Ebner-Priemer et al., 2009). The final sample consisted of 7 participants (M age = 22 years old, 86% female).

Recruitment

All procedures were approved by the Boston University Institutional Review Board (Boston University IRB 3103) and the study was preregistered with ClinicalTrials.gov (Identifier: NCT02060448). After being recruited through referrals and online research listings, participants completed several brief screening interviews to determine their eligibility and provided informed consent.

Study Design

This treatment study used a counterbalanced, combined-series single-case experimental design (Barlow et al., 2008) to test the effects of two emotion-focused interventions on NSSI. The study consisted of four phases: baseline (2 or 4 weeks), two 4-week interventions (weekly mindful emotion awareness and cognitive reappraisal sessions), and a 4-week follow-up. After the first (randomly assigned) intervention, participants either received the alternative intervention (if they did not evidence a clinically meaningful response in terms of NSSI) or entered follow-up. Participants provided an average of 86 days of EMA data.

EMA Design

A combination of an interval-contingent and event-contingent design was used measure NSSI acts. Participants completed a daily assessment prompted via text message and were instructed to self-initiate an entry whenever they experienced an urge to engage in NSSI or engaged in NSSI. All EMA data were collected with SymTrend (<https://www.symtrend.com>), a smartphone platform for real-time data collection. At the end of the study, participants received monetary compensation up to \$300 based on number of phases completed plus a \$100 bonus for $\geq 80\%$ compliance with EMA assessments. Participants provided EMA data on 94.1% of days in the study, resulting in 5.9% missing daily NSSI data overall.

EMA Measures

In the EMA protocol, NSSI was defined for participants as “purposely hurting yourself without wanting to die.” In both the daily assessment and participant-initiated reports, if participants reported engaging in NSSI, participants were asked about the function(s) of the NSSI act(s). If participants responded that they had engaged in NSSI since the last assessment, they were then asked, “Why did you hurt yourself?” Participants could select one or more of the following options: “To get rid of a bad thought/feeling” (ANR), “To feel something” (APR), “To escape task/people” (SNR), “To communicate with others” (SPR), and “Other” (followed by a text entry). Thus, the functions were assessed in a binary scale. For each NSSI act, participants were also asked, “How much did you hurt yourself as a way to get rid of bad thoughts/feelings?” (ANR) on a 1 (not at all) to 5 (extremely) scale. Thus, the intensity of only the ANR function was also assessed with a continuous scale.

STUDY 2: ADOLESCENTS WITH A HISTORY OF SELF-INJURY

Participants

Thirty adolescents and young adults (12 – 19 years old) participated in the study (Nock et al., 2009). Inclusion criteria were having NSSI thoughts in the past 2 weeks and having access to a computer. Of the 30 participants, we excluded 15 participants who reported engaging in NSSI less than three times during the study because the analyses used in this paper required at least three data points to be able to examine within-person variability (Ebner-Priemer et al., 2009). The final sample consisted of 15 participants (*M* age = 17 years old, 93% female).

Recruitment

All procedures were approved by the Harvard University Institutional Review Board. Participants were recruited via study advertisements in the community and online. Participants (and their parents for those under 18 years old) provided informed consent to participate in the EMA protocol during a brief laboratory session.

EMA Design

Personal digital assistants (PDAs) were used for EMA. Participants carried the PDA for 14 days. A combination of an interval-contingent and event-contingent design was used measure the functions of NSSI acts. Participants were prompted to fill out reports twice a day (at mid-day and end-of day) on NSSI. Participants were also instructed to self-initiate an entry whenever they experienced a self-injurious thought or behavior. All EMA data were collected with SymTrend. At the end of the 14-day monitoring period, participants were paid \$100 or were allowed to instead keep the PDA if their compliance with the signal contingent entries exceeded 80%.

EMA Measures

In the EMA protocol, NSSI was defined for participants as “harming yourself without wanting to die.” If participants responded that they had engaged in NSSI, they were then asked, to “Indicate why you did the behavior.” Participants could select one or more of the following options: “Rid of thought/feeling” (ANR), “Feel something” (APR), “Escape task/people” (SNR), “To communicate” (SPR), and “Other.”

STUDY 3: ADULTS WITH A HISTORY OF SUICIDAL BEHAVIOR

Participants

Participants were drawn from an initial sample of 54 adults who attempted suicide in the year before data collection began as part of larger IRB-approved study (Harvard University IRB 15-1975) on variability in momentary levels of suicidal ideation (Kleiman et al., 2017). To be included in the current analysis, participants had to have engaged in an NSSI act at least three times during the study period. The final sample consisted of 9 participants (*M* age = 25 years old, 78% female).

Recruitment

Participants were recruited from forums relating to self-harm or suicide on the website Reddit. Participants completed a series of screening forms to determine eligibility and provided informed consent online. The inclusion criteria for the study was the presence of at least one suicide attempt

in the past year, fluency in English, age of at least 18 years, and regular access to an Android or iPhone smartphone.

EMA Design

The EMA period was 28 days long. The study used an event-contingent design to record NSSI acts. Participants were told to self-initiate an entry whenever they experienced an NSSI urge or engaged in an NSSI act. All data were collected with the mEMA software (www.ilumivu.com) designed for Android and iOS smartphones. Participants received up to \$50 for the study.

EMA Measures

In the EMA protocol, NSSI was defined as “hurting yourself without wanting to die.” If participants reported an NSSI act, they were asked to “indicate how strong each reason was for hurting yourself without wanting to die” and were provided the following reasons: “to get rid of bad feelings” (ANR), “to feel something because I felt numb or empty” (APR), “to get out of doing something or to get away from others” (SNR), and “to communicate with someone else or to get attention, revenge, or a reaction” (SPR). The strength of each function was rated on 1 (*not strong [intense] at all*) to 5 (*very strong [intense]*) scale.

ANALYTIC STRATEGY

To examine question one (generalizability), we computed between-person intraclass correlations (*ICC*) for each NSSI function (ANR, APR, SNR, SPR). The *ICC* is an index of the proportion of variance due to between-person versus within-person differences. A higher *ICC* value indicates less within-person variability and more between-person variability. Various methods exist for estimating *ICC* exist (Wu et al., 2012). We estimated *ICC* with mixed effects models. For binary variables, we used logistic mixed effects models with the *lme4* package (Bates et al., 2015). For continuous variables, we used linear mixed effects models with the *lme4* package. *ICC* were calculated with the *performance* package (Lüdtke et al., 2021). One set of widely cited guidelines (Koo & Li, 2016) proposes that an *ICC* below 0.5 is low, between 0.5 and .75 is moderate, and between .76 to 1 is high.

We also quantified generalizability by computing overall function diversity scores for each participant. Diversity scores are quantified with the Gini coefficient which was computed with the *ineq* R package (Zeileis & Kleiber, 2014). Binary variables required no transformation to compute a Gini coefficient. For continuous variables, we transformed them into binary variables. We

recoded we recode values of 1 to 0 and values of 2-5 to 1. Diversity scores range from 0 to 1 with higher values indicating more diverse system (Benson et al., 2018). If all individuals had the same system of functions, all individuals would have the same GINI coefficient.

To examine question two (stability), we computed two metrics of within-person variability. For binary variables, we computed within-person means (*iMean*). We coded each binary variable as 0 = absent and 1 = present; therefore, a within-person means represents the proportion of observations that are in the present category. Stability could therefore either represent 1 (always present) or 0 (always absent). For continuous variables, we computed within-person root mean square of successive differences (*RMSSD*) (von Neumann et al., 1941) for each NSSI function (ANR, APR, SNR, SPR). *RMSSD* is a measure of variability from observation to observation. Therefore, a higher *RMSSD* value would indicate generally more within-person variability and specifically characterize variability as more frequent changes in NSSI functions from episode to episode.

To examine the co-occurrence of NSSI functions, we computed basic descriptive statistics (e.g., percentages) of NSSI acts in which single or multiple functions were reported.

Results

In Study 1, across 7 participants, 136 NSSI acts were reported. In Study 2, across 15 participants, there were 86 NSSI acts. In Study 3, across 9 participants, 49 NSSI acts were reported. Descriptive statistics and measures of variability for each function for each study are reported in Tables 1 and 2.

HOW MUCH DO THE FUNCTIONS OF NSSI ACTS VARY BETWEEN PEOPLE OVER TIME?

There were several consistent between-person findings. Across participants and studies, ANR was the only function reported by every participant in every study and by far the most frequently endorsed function (Tables 1 and 2). The two social functions (SNR and SPR) were endorsed less frequently than the two affective functions (ANR and APR). There were between-study differences in the endorsement of social functions with SPR being more frequently endorsed in Study 3 than in Study 1 and Study 2. Data from all three studies showed that NSSI functions varied substantially between people over time: the majority of *ICCs* for NSSI functions across studies showed moderate to high between-person variability (Tables 1 and 2). Across the three studies, 27 of the 31

Table 1
Descriptive and Variability Statistics for Nonsuicidal Self-Injury Functions (Study 1 & Study 2)

Study	Variable	% Endorsed	ICC	Mean <i>iMean</i>	Range <i>iMean</i>
1	ANR	95	0.77	0.90	0.33 – 1
1	ANR Intensity*	-	0.70	2.11	1.07 – 3.18
1	APR	13	0.73	0.26	0 – 1
1	SPR	4	0.80	0.10	0 – 1
1	SNR	15	0.85	0.33	0 – 1
2	ANR	66	0.11	0.66	0 – 1
2	APR	27	0.30	0.32	0 – 1
2	SPR	2	NA ⁺	0.02	0 – 1
2	SNR	13	0.25	0.14	0 – 1

Note: Multiple functions could be endorsed at the same time. ANR = automatic negative reinforcement, APR = automatic positive reinforcement, SPR = social positive reinforcement, SNR = social negative reinforcement.

* Measured dimensionally.

⁺ Cannot compute ICC because between-person variance equals zero.

Table 2
Descriptive and Variability Statistics for Nonsuicidal Self-Injury Function Intensity (Study 3)

Variable	<i>M</i>	<i>SD</i>	Range	ICC	Mean <i>RMSSD</i>	Range <i>RMSSD</i>
ANR	4.49	1.09	1-5	0.61	0.69	0-2.56
APR	3.13	1.57	1-5	0.40	1.67	0-4.00
SPR	1.68	1.3	1-5	0.49	1.01	0-2.83
SNR	1	0	1-1	NA ⁺	0	0

Note: All functions were measured dimensionally. ANR = automatic negative reinforcement, APR = automatic positive reinforcement, SPR = social positive reinforcement, SNR = social negative reinforcement.

⁺ Cannot compute ICC because between-person variance equals zero.

(87%) of the participants had different distributions of NSSI functions over time as quantified with the Gini coefficient.

HOW MUCH DO THE FUNCTIONS OF NSSI ACTS VARY WITHIN PEOPLE OVER TIME?

There were several consistent within-person findings. First, NSSI functions varied in how much they changed over time. Across all three studies, the APR function had one of the highest averages of within-person variability (Tables 1 and 2). Second, individuals differed in how variable their patterns of functions were over time with the majority of functions showing a wide range of *iMean* and *RMSSD* values for ANR, APR, SNR, and SPR (Tables 1 and 2). Third, the vast majority of individuals (84%) evidenced changes in functions from episode to episode over time (Figure 1, Figure 2, Figure 3).

HOW OFTEN DO THE FUNCTIONS OF NSSI ACTS CO-OCCUR OVER TIME?

For the first two studies, participants most often endorsed only one function for each NSSI act. In Study 1, only one function was endorsed for 77.9% of NSSI acts. In Study 2, only one function

was endorsed in 61.6% of NSSI acts. In Study 3, due to the dimensional measurement of functions, the co-occurrence of functions was operationalized as at least two function scores above a rating of 3 (i.e., the midpoint of the scale) during the same NSSI episode. Using this operationalization, only one function was endorsed in 57% of NSSI acts. This means that overall, participants endorsed more than one function at a time for 22% to 43% of NSSI episodes. ANR was the function that co-occurred with other functions most frequently.

Discussion

The findings from this study suggest that NSSI functions differ in how often they occur over time, how stable versus dynamic they are, and how likely they are to co-occur with other functions. The reinforcement processes for NSSI appears to be complex, multifaceted, and time-varying.

HOW MUCH DO THE FUNCTIONS OF NSSI VARY BETWEEN PEOPLE OVER TIME?

Our results for overall prevalence of NSSI functions are consistent with those from prior cross-sectional and longitudinal studies, indicating that ANR tends to be by far the most commonly

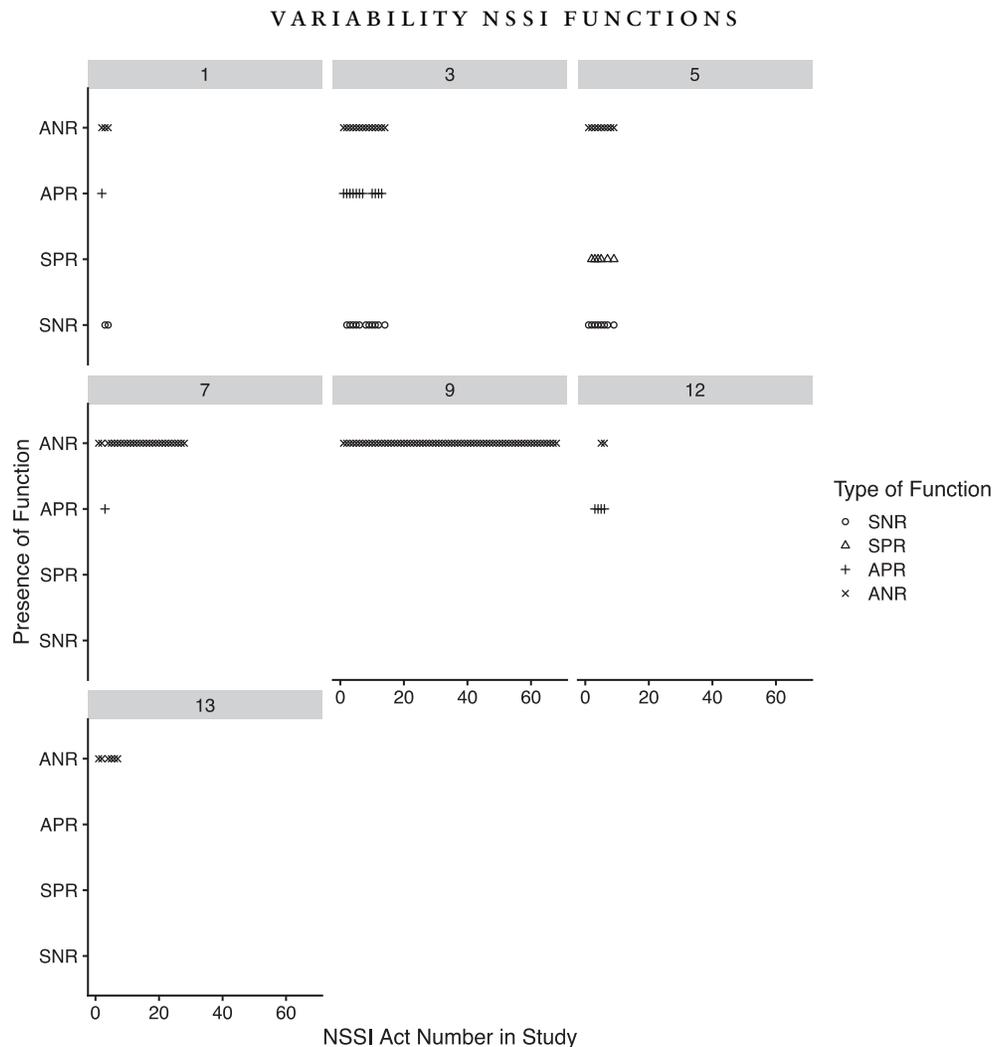


FIGURE 1 *Nonsuicidal Self-Injury Functions Over Time by Participant (Study 1)*. Note: The numbers in the gray lines are participant numbers. The x-axis represents the NSSI episode in the study. ANR= automatic negative reinforcement, APR = automatic positive reinforcement, SPR= social positive reinforcement, SNR = social negative reinforcement.

endorsed function of NSSI (Bentley et al., 2014; Taylor et al., 2018). In the current investigation, for the studies that assessed functions on a binary scale (Studies 1 and 2), 66 to 95% of observed NSSI acts were enacted for ANR (with or without other co-occurring functions). In the community-based adult study (Study 3), which assessed functions dimensionally, ANR had the highest mean rating of the four functions. Of note, the especially high prevalence of ANR in Study 1 may be at least partially due to the fact that outpatients were required to endorse ANR as a reason for engaging in NSSI for entry into the study. The high prevalence of ANR across participants has potential clinical implications. For example, if regulation of negative affect plays a role in all or the vast

majority of NSSI episodes, this would underscore teaching adaptive emotion regulation strategies as a key, relatively universal intervention for reducing NSSI.

Our findings also extend earlier work on prevalence of NSSI functions by presenting a more nuanced picture of the distributions of NSSI functions. Our data highlight and quantify individual differences in the functions of NSSI. For example, certain individuals only reported the ANR function for every NSSI episode. Other participants, however, reported a range of the different functions across different NSSI episodes. Demonstrating that individual differences exist for the functions of NSSI represents a foundational step towards better understanding the functions of

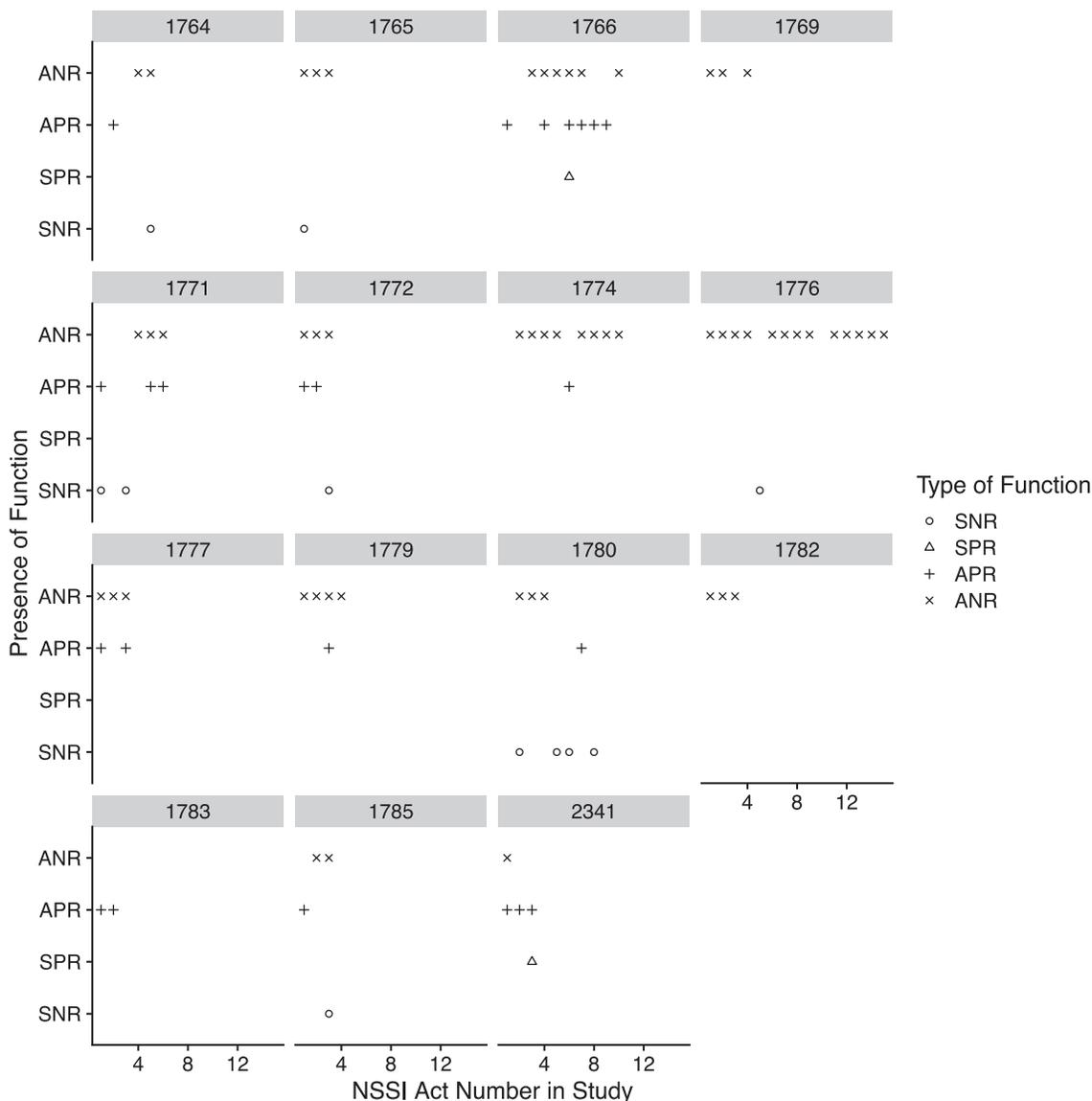


FIGURE 2 *Nonsuicidal Self-Injury Functions Over Time by Participant (Study 2).* Note: The numbers in the gray lines are participant numbers. The x-axis represents the NSSI episode in the study. ANR= automatic negative reinforcement, APR = automatic positive reinforcement, SPR= social positive reinforcement, SNR = social negative reinforcement.

NSSI and highlights the potential limitations associated with generalizing NSSI functions from one person to the next.

HOW MUCH DO THE FUNCTIONS OF NSSI VARY WITHIN INDIVIDUALS OVER TIME?

The second aim was to determine the degree to which functions of NSSI vary within people over time (i.e., stability of functions). There were three main findings regarding this aim.

First, the degree of within-person variability appears to vary by function type. Across all three studies, the APR function had the highest average measures of within-person variability. This suggests that some functions, such as APR, may be

more dynamic across time whereas other functions (e.g., ANR) may be more static. Second, the degree of within-person variability appears to vary across individuals. This means that some people engage in the same function more consistently whereas other individuals had more variability in the functions of their nonsuicidal self-injurious behavior over time. Across all studies (except for one function in Study 3), there was a relatively wide range of within-person variability for all functions. Once again, this highlights the existence of individual differences in the manifestations of NSSI functions over time. Third, we observed that dimensional measurement of NSSI functions appears to result in higher levels of within-person variability,

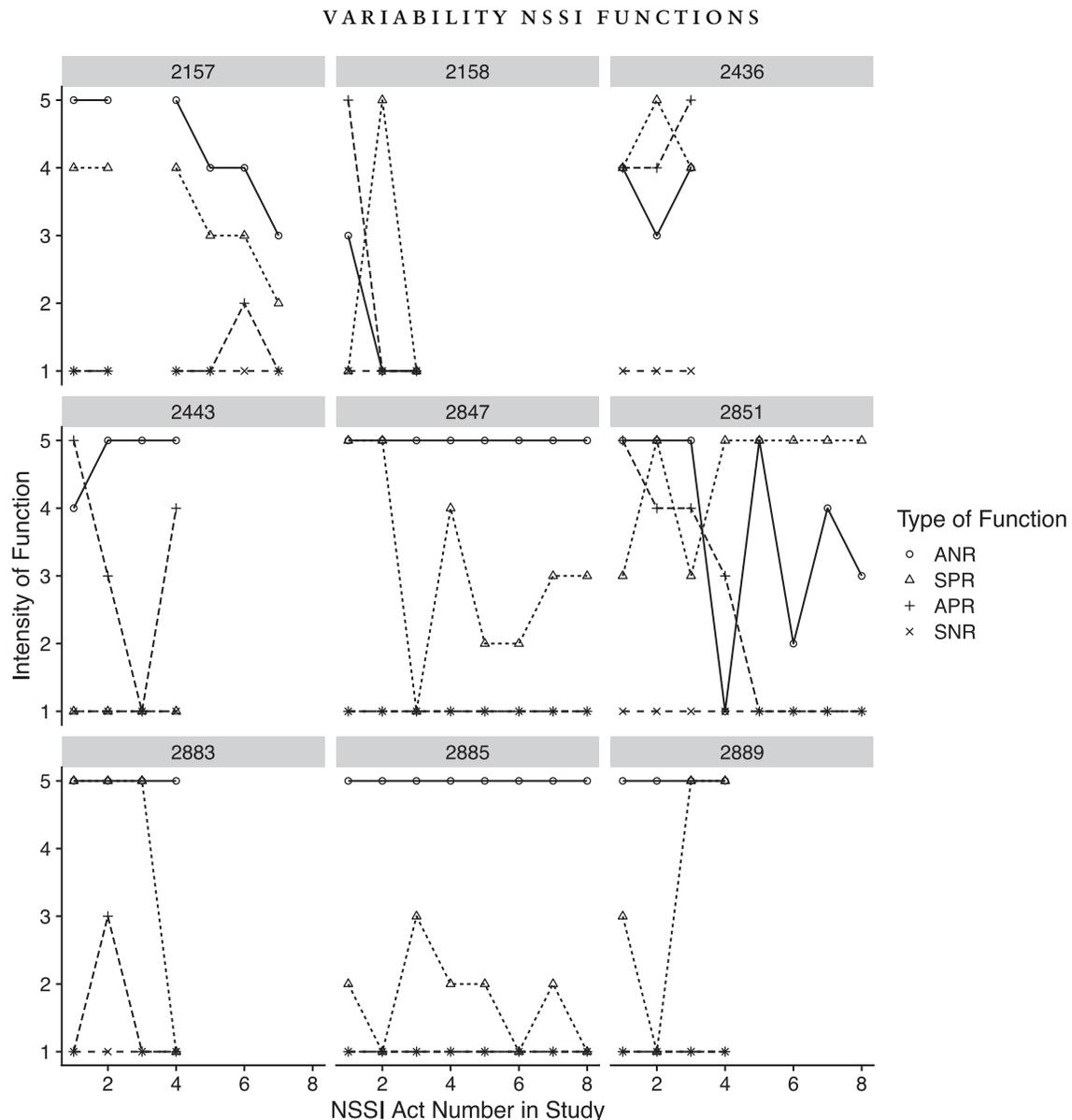


FIGURE 3 *Nonsuicidal Self-Injury Function Intensity Over Time by Participant (Study 3).* Note: This figure reflects intensity, not presence (as in Studies 1 and 2) because a dimensional measure was used in this study. The numbers in the gray lines are participant numbers. The x-axis represents the NSSI episode in the study. ANR= automatic negative reinforcement, APR = automatic positive reinforcement, SPR= social positive reinforcement, SNR = social negative reinforcement.

evidenced both by quantitative estimates and visual inspection of the figures. This may suggest that NSSI functions are better conceptualized as a continuous phenomenon rather than binary phenomena in which a function is present or absent (Krueger & Piasecki, 2002). Further empirical work, however, is required with more in-depth measurement and advanced statistical modeling (e.g., taxometrics; Ruscio et al., 2013) to determine if NSSI functions are better conceptualized as binary or dimensional.

These data advance our understanding of variability in NSSI functions as highly person- and context-specific, thus emphasizing the importance of idiographic research methods such as those presented here (Barlow & Nock, 2009; Bentley et al., 2019; Molenaar & Campbell, 2009). From a treatment perspective, these findings highlight the importance of ongoing functional analysis for individual NSSI episodes over time (Hayes et al., 2018), and providing a range of skills/strategies for people struggling with NSSI that can be

implemented, tailored, or prompted (perhaps using a just-in-time adaptive intervention approach, which we return to below; Nahum-Shani et al., 2018) according to the function(s) of NSSI for a given episode.

HOW OFTEN DO THE FUNCTIONS OF NSSI CO-OCCUR OVER TIME?

Our third aim was to examine the frequency with which functions of NSSI co-occur over time (i.e., co-occurrence of functions). Across the three studies, 22.1% to 42.9% of NSSI acts were enacted for more than one function. To our knowledge this is the first time that function co-occurrence (in individual NSSI episodes) has been demonstrated empirically. This finding has important clinical implications. Individuals who endorse multiple functions within a given NSSI episode would likely need to learn and practice both emotion management and interpersonal skills. Dialectical Behavior Therapy (DeCou et al., 2019) and Interpersonal Therapy (Lipsitz & Markowitz, 2013) are two therapeutic frameworks that include both emotion management and interpersonal strategies, and thus may be effective at reducing NSSI for individuals who report multiple NSSI functions. Additionally, the co-occurrence of ANR with other functions was the most common pattern across all three studies. This begs the question of whether social functions (i.e., reinforcement processes) for engaging in NSSI may be in part driven by (or at least associated with) underlying deficits in emotion regulation. Additionally, and as previously noted, this finding may point to teaching adaptive emotion management skills as an optimal (e.g., most time-efficient and universally relevant) intervention for reducing NSSI. There is still a need, however, for further research on the individual and situational factors that influence whether a person engages in NSSI for multiple functions or one function.

These results and the corresponding clinical implications must be considered in the context of several limitations. First, functions were exclusively assessed via self-report as opposed to more objective passive measures (e.g., physiological indicators of psychological arousal before/during/after NSSI) (Rough et al., 2019). Though EMA is an improvement on traditional from retrospective self-report measures, it doesn't eliminate recall bias, impression management, or mood congruent reporting. Second, there were variable assessment methods across different studies, limiting the degree to which we could make direct cross-study comparisons. Third, there were relatively small sample sizes. Fourth, the level of potential reactivity to EMA (Calamia, 2019) is unknown

within the context of NSSI. Finally, we did not measure the function of self-punishment, which is another frequently reported function of NSSI (Burke et al., 2021).

Despite these limitations, this study has key strengths that maximize its incremental contribution to the existing literature on NSSI and NSSI functions. We present data from three distinct samples (outpatients, community-based adolescents, and community-based adults), thus allowing us to examine individual and temporal granularity in functions in a range of samples. Furthermore, by including only actively self-injuring participants, we were able to observe a relatively large overall number of NSSI acts (271) across a relatively small number of participants (31) and relatively short time frames (2 to 20 weeks), thereby maximizing the richness of captured information on NSSI functions. Finally, as previously described, each of these studies employed EMA to assess phenomena of interest, which allowed for this never-before-available fine-grained, idiographic analysis of the variability in NSSI functions over time. This represents an important extension of previous work on NSSI functions, which is limited to either cross-sectional designs or (only more recently and for very few studies) longitudinal research with small numbers of retrospective assessments over extended periods of time (Taylor et al., 2018).

This investigation also sets the stage for several key directions for future work. As alluded to above, studies that incorporate objective, continuous, behavioral real-time measures may provide more specific insights into the functions of NSSI (Onnela & Rauch, 2016; Rough et al., 2019). This line of research would not only have the potential to reveal important classes (or phenotypes) of NSSI functionality, but may also facilitate ongoing assessment and functional analysis of NSSI within a treatment context (Bentley et al., 2017; Hayes et al., 2018). There is increasing interest in the development and testing of real-time (or just-in-time adaptive) interventions for a variety of behavioral and psychological phenomena (Nahum-Shani et al., 2018). It can be difficult for people to recall and correctly use skills learned in traditional or in-person therapy when in distress (Zieve et al., 2019). Distress is especially heightened before NSSI (Armey et al., 2011), and NSSI tends to work in the short-term to reduce distress (Hepp et al., 2020), as evidenced by the frequency endorsement of ANR in this study. Real-time "reminders" and supports to facilitate specific emotion regulation skills practice (e.g., opposite action, relaxation, distraction) when it is needed the most (e.g., when

distress is high) may be needed. Real-time interventions via smartphones, then, could help people access the skills previously learned in in-person therapy when they need them. Given that the findings from this study suggest that the functions of NSSI vary over time, different skills may be needed at different levels (and contexts; e.g., contributing situational factors) of distress. Therefore, personalized interventions that target the functions of NSSI in real-time, when they are most needed, could be effective in reducing NSSI (Coppersmith et al., 2021).

Thus, new technologies and experimental designs hold the potential for more detailed descriptions of the functions of NSSI and novel interventions to target them. Given the clinically serious nature and alarmingly high prevalence of NSSI, improved approaches to assessment and treatment of this behavior could have a significant public health impact.

Conflict of Interest Statement

The authors declare that there are no conflicts of interest.

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