MIND-WANDERING AND MOOD REPAIR:

THE ROLE OF OFF-TASK THOUGHT IN THE SUSTAINMENT OF NEGATIVE MOOD

By

Erik Knight Wing

Submitted to the graduate degree program in Clinical Psychology and the Graduate Faculty of the University of Kansas in partial fulfillment of the requirements for the degree of Master of Arts.

Chairperson Stephen S. Ilardi, Ph.D.

Kelsie T. Forbush, Ph.D.

Rick E. Ingram, Ph.D.

Date Defended: 5/10/2017

The Thesis Committee for Erik Knight Wing

certifies that this is the approved version of the following thesis:

MIND-WANDERING AND MOOD REPAIR:

THE ROLE OF OFF-TASK THOUGHT IN THE SUSTAINMENT OF NEGATIVE MOOD

____

Chairperson Stephen S. Ilardi, Ph.D.

Date approved: 5/10/2017

Abstract

Objectives: Mind-wandering, defined as a mental state encompassing task-unrelated and self-generated thought, is a ubiquitous cognitive phenomenon. Previous research has found a robust association between mind-wandering episodes and concurrent negative mood, such that increases in negative affect are predicted by increases in both mind-wandering frequency as well as off-task thought content focused on negative, past events. However, less is known about the function of mind-wandering among individuals who have already entered a negative mood state, or the role of mind-wandering in sustaining previously generated negative mood. Accordingly, the primary purpose of the present work was to investigate the relationship between mind-wandering (i.e., the frequency and content of off-task thought) and mood repair (i.e., change in negative affect over time) following the induction of a negative mood state.

Methods: Sixty-seven participants underwent a negative mood challenge during which a personal, negative event from their past was remembered while listening to negatively-toned music. Participants then completed a choice reaction time task that was low in cognitive demand. Intermittently during the task, thought probes prompted participants to report on the occurrence of off-task thoughts and the content thereof, along with their current levels of positive and negative affect. Participants additionally completed the Beck Depression Inventory-2nd Edition (BDI-II) as well as a working memory task (i.e., dual *N*-back) prior to the mood induction. Multilevel growth modeling analyses were utilized to evaluate the degree to which the temporal growth of negative affect was explained by mind-wandering frequency and content. Models were fitted to three versions of the dataset based on group-level indicators of mood-repair: a *full* dataset encompassing all data, a *repair* dataset encompassing data for the time period prior to mood repair, and a *post-repair* dataset encompassing data following the return to baseline levels of negative affect.

Results: Results indicated that mind-wandering frequency did not predict the sustainment of previously generated negative mood. In both the full and repair models, higher levels of mind-wandering frequency predicted higher levels of negative affect *across time*, but mind-wandering frequency was not found to influence change in negative affect *over time* (e.g., sustainment). Likewise, increased reporting of negative, past-oriented mind-wandering content was found to predict greater levels of negative affect in all three models, but did not predict changes in negative affect over time. Higher BDI-II scores and greater working memory task performance further predicted greater overall levels of negative affect across time. However, an exploratory analysis revealed that as the rate of change in mind-wandering increased (i.e., the slope of mind-wandering frequency became more positive) the linear growth of negative affect over both the full and repair periods increased (i.e., greater negative mood sustainment). This association was not found to be statistically significant in the post-repair model, indicating that the rate of mind-wandering change over time was specific in predicting the sustainment of previously generated negative mood.

Conclusion: These findings suggest that the rate of change in mind-wandering frequency, rather than its absolute level, may play an important role in the sustainment of previously generated negative mood. This evidence for the role of mind-wandering in negative mood sustainment is discussed in terms of both its theoretical and clinical implications.

Keywords: mind-wandering, negative mood, mood induction, mood repair, affective dynamics

Acknowledgements

First and foremost I would like to thank my thesis advisor, Dr. Stephen Ilardi, for his boundless patience and generosity throughout the thesis process. Additionally, I would like to thank the other members of my thesis committee, Dr. Kelsie Forbush and Dr. Rick Ingram, for their invaluable input throughout the course of the project.

I would also like to acknowledge both Daniel Reis and Michael Namekata for their personal and professional support. Further, I thank Ansley Bender, Craig Lawless, and Katie Schneider for their tireless work in data collection for the research study. Finally, I thank my family, most especially my parents, Karen and Mark Wing, for always believing in me.

Table of Contents

Mind-Wandering and Mood Repair:

The Role of Off-Task Thought in the Sustainment of Negative Mood

The phrase "stream of thought," coined by William James (1890), refers to the continuity of wakeful, human consciousness. More than a century later, James' metaphor continues to guide the scientific search for determinants of the properties of this stream. One useful dichotomization in this search has been the separation of mental states that reflect on-task, in-the-moment thought processes from those representing ideas detached from present sensory experience. These latter mental states are considered forms of task-unrelated thought (TUT), and when TUT arises from a self-generative process (i.e., not externally cued from a non-task sensory experience), the resulting mental state can be appropriately termed, "mind-wandering" (Smallwood & Schooler, 2014). Less formally defined, mind-wandering represents an episodic occurrence, when, "attention drifts from its current train of thought (often an external task) to mental content generated by the individual rather than cued by the environment" (Smallwood & Schooler, 2014, p. 3). The usefulness of mind-wandering as an academic concept derives from its service as a marker in the otherwise constant ebb and flow of consciousness; a marker by which the causes and consequences of different mental states can be elucidated.

Consequences of a Wandering Mind

The ability to engage in thoughts unrelated to the here-and-now may have conferred an array of evolutionary benefits. These could include enhanced creative and critical thinking (Baird et al., 2012), planning (Baird, Smallwood, & Schooler, 2011), and development of a self-concept through memory consolidation (Smallwood & Andrews-Hanna, 2013). Attentional detachment has also been theorized to play a major role in the development of symbolic meaning, language, time-binding (i.e., an ability to separate past, present, and future thought content) and a conscious awareness of the self (Becker, 1971).

Although mind-wandering is a normal phenomenon, specific individual differences in its frequency and content have been associated with mood disruption and psychopathology. For example, a common feature of depressive disorders is frequent mental rumination concerning overwhelmingly negative content (Spasojević & Alloy, 2001). Compared with healthy controls, dysphoric participants have shown increased mind-wandering frequency and greater physiological arousal during mind-wandering periods (Smallwood, O'Connor, Sudbery, & Obonsawin, 2007). Additionally, the observed association between negative mood and past-oriented thought content appears to be stronger at higher levels of dysphoric symptomatology (Smallwood & O'Connor, 2011). Likewise, the hallmark of pathological anxiety is chronic, excessive worry that overestimates the potential danger of current and future events (American Psychiatric Association, 2013). Mind-wandering has been found to increase in frequency when participants are made aware of an upcoming negative event, and mind-wandering content related to the dreaded event led to greater sustainment of negative emotion over time (Stawarczyk, Majerus, & D'Argembeau, 2013).

Should all forms of maladaptive thought be characterized as mind-wandering (Ottaviani & Couyoumdjian, 2013)? Some researchers posit that rumination and worry are best considered forms of "perseverative cognition," categorically distinct from non-pathological mind-wandering (Ottaviani, Shapiro, & Couyoumdjian, 2013; p. 38). Although it is certainly worthwhile to evaluate the causes and consequences of non-pathological mind-wandering in itself, Ottaviani et al. (2013) do not deny the shared attentional mechanisms supporting both perseverative cognition and non-pathological mind-wandering. Additionally, if one accepts the definition of mind-wandering as a period of task-unrelated, self-generated thought (Smallwood & Schooler, 2014), it becomes difficult to deny that some forms of perseverative, ruminative cognition meet full criteria for a mind-wandering episode. Therefore, within the given operational definition of mind-wandering, there are both adaptive and maladaptive forms; the latter of which may constitute rumination or pathological worry.

Mind-Wandering Frequency

The cardinal metric by which individual mind-wandering profiles are evaluated is the *frequency* of off-task thinking. Current estimates, utilizing ecologically-valid methods of inquiry, indicate that the average adult spends 25-50% of their waking life in a mind-wandering state (Kane et al., 2007; Killingsworth & Gilbert, 2010; Smallwood & Schooler, 2014). Although mind-wandering can be considered a nearly ubiquitous phenomenon, this range in mind-wandering frequency is indicative of significant variation both between and within individuals.

One of the most commonly studied predictors of mind-wandering frequency is working memory capacity (WMC). Several studies, primarily conducted by cognitive psychologists in assessments of task performance (e.g., reading tasks), have found increased mind-wandering frequency during task performance to be predictive of lower WMC (Mikulincer, 1989; McVay, Kane, & Kwapil, 2009; McVay & Kane, 2012). However, a study by Kane and associates (2007) qualifies this main effect, as WMC was found to interact with task-related cognitive demand to predict mind-wandering frequency. Kane et al. (2007) found that when the cognitive demand of a task was high, individuals with high WMC showed reduced frequency of mind-wandering than did low WMC individuals. However, during the completion of tasks low in cognitive demand, those with high WMC mind-wandered with *greater* frequency than those with low WMC (Kane et al., 2007). Therefore, it appears important to account for both WMC and task-related cognitive demand in examining rates of mind-wandering frequency.

The other main predictor of mind-wandering frequency is negative mood. Despite the existence of an interaction between WMC and task-related cognitive demand, WMC does not appear to moderate the effect of negative mood on mind-wandering frequency; that is, negative mood has been associated with more frequent mind-wandering regardless of WMC categorization (Kane et. al., 2007). Furthermore, in a seminal work by Killingsworth and Gilbert (2010), 2250 adult participants were asked to respond to experience-sampling probes with reports of current mood, current activity, and current focus of their thinking (i.e., on- or off-task). Two important findings emerged. First, participants reported being less happy when probed during mind-wandering episodes than during probes when attention was on-task (Killingsworth & Gilbert, 2010). Second, participants' reported happiness level during probes was less closely related to their current activity than it was to their mind-wandering (or absence thereof) during the activity. Specifically, "people's activities explained 4.6% of the within-person variance in happiness and 3.2% of the between-person variance in happiness, but mind-wandering explained 10.8% of within-person variance in happiness and 17.7% of between-person variance in happiness" (Killingsworth & Gilbert, 2010, p. 1).

Several studies have now established a general, positive correlation between mind-wandering frequency and negative mood (Smallwood, O'Connor, Sudbery & Obonsawin, 2007; Killingsworth & Gilbert, 2010; Smallwood & O'Connor, 2011). Moreover, research in this area has largely supported the bi-directionality of this effect: mind-wandering appears to both precede (Ruby, Smallwood, Engen, & Singer, 2013; Stawarczyk, Majerus, & D'Argembeau, 2013) and follow (Smallwood et al., 2007; Smallwood & O'Connor, 2011; Poerio, Totterdell, & Miles, 2013) negative mood.

Mind-Wandering Content

The intertwinement of cognitive and emotional states in the mind-wandering literature is not in itself a novel finding. The idea that particular kinds of thoughts can influence the experience of emotion is inherent to many influential cognitive theories of affective regulation (e.g., Beck, 1979). Likewise, the theory of mood-dependent memory is well substantiated (Eich & Metcalfe, 1989; Eich & Macaulay, 2000) and, along with the broaden-and-build hypothesis of positive emotion (Fredrickson, 2001), predicts differential patterns of thinking in correspondence with varying mood states. On the other hand, recent work has found that some particular forms of mind-wandering are not predictive of subsequent increases in negative emotion (Ottaviani & Couyoumdjian, 2013; Poerio, Totterdell, & Miles, 2013). Taken together, this work suggests a need to investigate individual differences in mind-wandering at a finer level of analysis. One question of particular importance: does the *content* of one's mind-wandering predict its emotional consequences?

Challenging the general association between mind-wandering and negative mood, Poerio et al. (2013) found that mind-wandering only predicted subsequent negative mood when its content was negatively valenced. Moreover, Ottaviani et al. (2013) found that mind-wandering failed to predict negative mood or depressive symptomatology when it was differentiated from persistent negative thinking (i.e., perseverative cognition). Although a main effect for the valence of mind-wandering content on its emotional consequences is parsimonious, recent work by Ruby et al. (2013) serves to qualify this observed association.

Initially, Ruby et al. (2013) replicated previous work, with the finding that negative mind-wandering content is more predictive of subsequent negative emotion than is mind-wandering consisting of positive thought content. However, this observed effect was moderated by both the temporal orientation and interpersonal nature of the mind-wandering thought content. Specifically, mind-wandering that was past-oriented and other-related resulted in increased negative affect, even if the valence of thought content was positive (Ruby et al., 2013). Additionally, future-oriented, self-related thoughts resulted in decreased negative affect, even if the valence of thought content was negative (Ruby et al., 2013). Therefore, in predicting the emotional consequences of mind-wandering, it may be important to evaluate the content of mind-wandering periods for valence, temporal orientation, and interpersonal nature.

Measuring Mind-Wandering

Inasmuch as mind-wandering is a task-unrelated and self-generated cognitive phenomenon, it does not lend itself well to direct experimental manipulation (Smallwood & Schooler, 2014). That is, the use of mind-wandering as an independent variable that can allow for causal inferences is intrinsically limited, since any direct manipulation (e.g., a cue for the participant to begin a mind-wandering episode) would render the episode unrepresentative of an ecologically valid period of mind-wandering as conceptualized by the field. Therefore, investigators tend to employ alternative methods, utilizing manipulations that can influence both the frequency and the type of mind-wandering that occurs.

One of the most common manipulations involves varying the degree of cognitive demand an external task imposes on the participant. Research has supported the notion that mind-wandering is more likely to occur during tasks of low cognitive demand than during tasks that require one’s full attention to complete successfully (McVay & Kane, 2012). Likewise, because of the observed association between unhappiness and increased frequency of mind-wandering (Smallwood et al., 2007; Killingsworth & Gilbert, 2010), negative mood inductions can be utilized at the beginning of an experimental session to induce increased mind-wandering (Smallwood & O'Connor, 2011). Both aforementioned strategies – manipulating the participant's level of cognitive demand as well as their mood – can serve as indirect manipulations of mind-wandering frequency as well as its content.

Regardless of the specific form of manipulation, experience sampling is commonly used by investigators to assess the frequency and content of participant mind-wandering episodes. Experience sampling refers to collecting in-the-moment self-reports of participant experience (Smallwood & Schooler, 2014). In its simplest form, participants are interrupted during a task and probed about whether or not they were on-task. However, such probes can be expanded to gauge the content of off-task thoughts, such as their temporal orientation (e.g., past vs. future) and interpersonal nature (e.g., self vs. others; Ruby et al., 2013).

Novelty of the Current Study

Although several studies have established an association between mind-wandering and negative mood (Smallwood et al., 2007; Killingsworth & Gilbert, 2010; Smallwood & O'Connor, 2011), there exists an array of possibilities regarding the role of mind-wandering in *sustaining* negative mood. For example, when engaged in a task that evokes negative emotion – such as distress or boredom – mind-wandering may arise from a natural inclination to remove oneself (i.e., mentally) from a negative stimulus (Eastwood, Frischen, Fenske, & Smilek, 2012; Wilson et al., 2014). In this context, we would expect to observe an association between mind-wandering and negative mood at a cross-sectional level of analysis, and yet the act of mind-wandering could actually function to alleviate the negative affect with which it is associated. On the other hand, the thoughts that occur during mind-wandering often serve to sustain or even perpetuate negative affect (Ruby et al., 2013; Stawarczyk et al., 2013). Therefore, much ambiguity continues to exist regarding the relationship between mind-wandering and the temporal dynamics of affect (Davidson, 1998). For clinically inclined researchers, the utility of mind-wandering research will depend largely on its ability to elucidate why, when, and how mind-wandering promotes change in negative mood *over time* (Smallwood, 2013).

The primary aim of the present study was to specify the kind of mind-wandering, as defined by its frequency and content, that promotes changes (i.e., rise, sustainment, or repair) in negative affect over time. Participants completed a choice reaction time (CRT) task that was low in cognitive demand. Throughout the task, experience sampling thought probes prompted participants to assess their current affective state, as well as the occurrence and content of mind-wandering periods. Unique to the present study, this experience sampling methodology was combined with a negative mood challenge conducted prior to CRT task administration. The mood induction required participants to recall a previously experienced negative life event while listening to negatively-toned music. Thus, the novelty of the present study resides in its combining a retrospectively-based negative mood challenge with subsequent tracking of both affective and mind-wandering dynamics. That is, the current investigation allowed for the tracking of mood repair – characterized by the trajectory of negative affect during the CRT task – as well as an analysis of its association with individual differences of mind-wandering profiles (i.e., frequency and content).

An additional feature of the present study was an investigation of the individual difference determinants of mind-wandering profiles that arise under the context of previously generated negative mood. Participants completed the Beck Depression Inventory-2nd Edition

(BDI-II; Beck, Steer, & Brown, 1996) and a working memory task (i.e., dual *N*-back) to assess dysphoric symptomatology and working memory capacity (WMC), respectively. These measures were proposed to influence profiles of mind-wandering as they represent indices of general unhappiness and working memory, two factors implicated in both mind-wandering frequency and content (Kane et al., 2007).

Hypotheses

To the author's knowledge, no extant study has examined variability in levels of negative affect as a function of mind-wandering frequency or content following a retrospectively-based negative mood challenge. Furthermore, no study has examined the predictive nature of mind-wandering frequency or content in the change of negative affect over time (i.e., negative mood *sustainment*) during the specific time period in which a previously generated negative mood is being repaired. Using both mind-wandering frequency and mind-wandering content as primary predictor variables of negative affect, a multilevel growth model was constructed for three distinct datasets: (a) the full dataset including all data (full model); (b) a dataset containing only data prior to full mood recovery (i.e., defined at the group level) following the negative mood induction (repair model); and (c) a dataset containing only data following mood recovery (post-repair model). These models also included measures of dysphoric symptomatology and working memory capacity, operationalized by BDI-II scores and dual *N*-back performance, respectively, to examine the degree to which these trait-level variables may moderate the effect of mind-wandering frequency and content on negative affect.

Hypothesis 1. First, I hypothesized that more frequent mind-wandering would be predictive of increased negative affect change *over time*, within all three datasets. The repair model was of most interest to the current study, as the sustainment of negative mood was operationalized as the *trajectory* of negative affect over the course of the repair period (i.e., utilizing the repair dataset). Therefore, a significant statistical interaction between mind-wandering frequency and the linear growth term in the repair model would be indicative of an important role of mind-wandering frequency in the sustainment of a previously generated negative mood. Alternatively, if mind-wandering frequency was a statistically significant predictor of negative affect, but did not interact with a negative affect growth term, it would indicate that mind-wandering frequency was predictive of the overall level of negative affect (i.e., a main effect), without being indicative of negative affect sustainment (i.e., trajectory) over time. Although no study has investigated the nature of this association in the context of a mood repair period, this hypothesis was based on previous research indicating that higher mind-wandering frequency may precede greater increases in negative affect, as compared to lower levels of mind-wandering frequency (Ruby et al., 2013, Stawarczyk et al., 2013).

Additionally, it was predicted that mind-wandering frequency would explain unique variance in negative affect as compared to both dysphoric symptomatology and working memory capacity. That is, it was predicted that when dysphoric symptomatology and working memory capacity were included in each model, mind-wandering would remain a statistically significant predictor of negative affect. Based on the work of Kane and associates (2007), it was further predicted that greater levels of both dysphoric symptomatology and working memory capacity would predict greater overall levels of negative affect, throughout the entire task period (i.e., all datasets).

Hypothesis 2. Second, I hypothesized that past-oriented, negatively valenced mind-wandering content would be predictive of greater levels of negative affect *across time* (i.e., a main effect) within all three datasets. This hypothesis was based on the work of Ruby and colleagues (2013) that found past-oriented, negatively valenced thought content to be predictive of overall levels of negative mood. However, I additionally predicted that mind-wandering content would not interact with changes in negative affect *over time* (e.g., negative mood sustainment) within any of the three datasets. This hypothesis was based on research indicating that the content of off-task thought does not in itself explain change in negative affect over time (Ottaviani & Couyoumdjian, 2013; Poerio, Totterdell, & Miles, 2013; Ruby et al., 2013). Therefore, it was expected that when the content of off-task thought was separated from the frequency of its occurrence, it would fail to be predictive of changes in negative affect *over time*.

The variable of interest representing mind-wandering content was measured by prompting the participant, during the CRT task, to rate the degree to which they were thinking of their personal, past negative event which they selected for use in the mood induction procedure. Additionally, it was again predicted that mind-wandering content would explain unique variance in negative affect as compared to both dysphoric symptomatology and working memory capacity.

METHOD

Participants

Seventy-nine participants were recruited for the study.[1] All participants were undergraduates at the University of Kansas currently enrolled in a psychology course. The study was made available to qualifying participants on the University of Kansas Research Participation System (i.e., SONA Systems). All participants completed the study for course credit.

Inclusion & exclusion criteria. To ensure adequate understanding of task instructions, fluency in English was an inclusion criterion for study participation. Additionally, all

[1] Sixty-seven participants were ultimately used for data analysis. More detail is provided in the "Data Exclusion" section.

participants were at least 18 years old at the time of consent. Participants were excluded from study participation if they reported, at the beginning of the study session, taking psychostimulant medication (e.g., Ritalin, Adderall, etc.) for medical or recreational purposes within the previous 24 hours. Previous work indicated that individuals currently under the influence of stimulant medication are not likely to express patterns of off-task thinking reflective of their normal cognitive functioning (Rapport & Kelly, 1991). Stimulant medication use was therefore excluded to prevent associations between mind-wandering and mood repair not representative of the general population.

Furthermore, the Beck Depression Inventory-2nd Edition (BDI-II; Beck et al., 1996) was administered to participants at two time-points; first, as part of a screening survey prior to study enrollment and, second, at the beginning of the experimental session. Participants scoring 20 or greater on the BDI-II at either time-point were excluded from study participation. The primary purpose of this exclusion criterion was to prevent severely depressed individuals from undergoing a negative mood challenge. Second, a cardinal aim of current study was to examine the trajectory of negative affect following a negative mood induction. Those currently experiencing elevated dysphoric symptomatology were expected to present with baseline levels of negative affect that were elevated relative to healthy populations. This depressotypic pattern may have produced a ceiling effect, resulting in relatively abbreviated recovery times. Furthermore, such recoveries would not reflect a return to the same neutral affective state which characterizes the baseline levels of non-depressed participants.

Procedure & Stimuli

Participants completed all research activities in a single visit to a research laboratory at the University of Kansas (See Appendix A for a flow chart of study procedure). The duration of the experimental session was 90 minutes. After arrival and consent, participants were seated in front of a computer screen with access to a keyboard and mouse.

Preliminary questionnaires. First, via Qualtrics questionnaire administration software, participants completed a mood check and the BDI-II. The mood-check consisted of two questions, "How positive are you currently feeling?" and, "How negative are you currently feeling?" on a Likert scale (1 = Not at all, 9 = Extremely). This mood check was used to gauge baseline mood and was repeated throughout the session as well as during the choice reaction time (CRT) task as part of the thought probes. Before study progression, the BDI-II total score was checked to ensure the inclusion criterion was met.

Working memory task. Participants then completed a dual *N*-back task designed to assess working memory capacity (WMC). The dual *N*-back task administered in the current study was modified from the dual *N*-back task administered in Experiment 1 of Jaeggi, Buschkuehl, Perrig, and Meier (2010) and presented using E-Prime stimulus presentation software. Both visuospatial and auditory material were used as stimuli and presented simultaneously. Visuospatial stimuli consisted of blue squares appearing at one of eight fixed positions on the computer screen surrounding a constantly displayed fixation cross. The auditory material consisted of consonants (c, g, h, k, p, q, t, w) spoken by a female voice. These consonants were chosen based on pilot testing by Jaeggi et al. (2010) confirming their auditory distinctiveness.

Participants were provided with standardized instructions for the task (Jaeggi et al., 2010). Participants were instructed to respond via keypress when the current stimulus matched the stimulus presented *N* trials prior. Separate keys were designated for visuospatial and auditory material, requiring participants to respond separately for each stimulus modality. Three difficulty levels were sequentially presented, with participants completing 40 trials each of *1*-back, *2*-back, and *3*-back difficulties. Each trial contained visuospatial and auditory stimuli presented simultaneously for 500ms, followed by an interstimulus interval (2500ms). All difficulty levels were matched for the number of targets (33%) and non-targets (67%), as well as for distractors. Performance on the task was operationalized as accuracy (i.e., percentage of hits minus percentage of false alarms) averaged across all three difficulty levels.

Choice Reaction Time task training period. Following the working memory task, participants were trained on the upcoming choice reaction time (CRT) task. Although the mood induction took place prior to the CRT task, training participants on the CRT task prior to the mood induction allowed for a faster transition between the mood induction and the actual CRT task. This training session was computer-based and instructed the participant on the stimuli and thought probes they would encounter during the CRT task.

Mood induction. Next, participants underwent a negative mood induction procedure. Immediately prior to the mood induction task, participants again completed a mood check as well as the Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988). For the mood induction, the current study utilized an identical procedure to Ingram and Ritter (2000), requiring participants to wear headphones and listen to negatively-toned music. Participants were instructed to remember and think about a negative event that took place at some point in their past while listening to the music. The music was comprised of two selections from the *Field of Dreams* soundtrack and had an eight minute duration. The mood check and PANAS were re-administered after the mood-induction procedure and the difference between the two scores was analyzed as a manipulation check of the mood induction.

Choice Reaction Time task. Following the mood induction, the CRT task with thought probes was administered. Similar to the CRT task employed in Ruby et al. (2013), black and green digits were presented serially on a computer screen. Black digits were displayed for 1000 ms, while green digits were displayed for 2000 ms. Participants were instructed to push one of two buttons to indicate whether the digit was odd or even, but only for green digits. Participants were instructed not to respond when a black digit was presented. Stimuli were separated by a fixation cross (2000 ms), and black and green digits were displayed at a 6:1 ratio, making the task low in cognitive demand.

During the CRT task, participants were interrupted with ten thought probes containing ten questions each using a nine-point Likert scale. The thought probes were displayed in five sequential screens (Appendix B) and advanced after the participant entered all requested information (i.e., self-paced). Thought probes were displayed in a fixed pattern, occurring once every 60 seconds. Although the total task time was variable because the thought probe screens were self-paced, the total CRT task duration was approximately 16 minutes.

Post-study questionnaires. After the CRT task, participants once more completed the PANAS as well as a final mood check. Additionally, participants were asked to describe the specific negative event they chose for the negative mood induction, in as much detail as they were comfortable providing. This event-elaboration process has been shown to help alleviate lingering dysphoria-related effects from the mood induction (Pennebaker, 1997). Participants then filled out a demographics survey that collected gender, race, ethnicity, and socio-economic status information. Finally, participants were debriefed, thanked for their time, and excused from the experimental session.

Statistical Analyses

Multilevel growth modeling (MLM) for repeated measures was the primary method of analysis for the current study. MLM is a commonly used mixed modeling approach to determine the between-subjects factors which uniquely explain the variance of a within-subjects factor as it changes over time (Curran, Obeidat, & Losardo, 2010). For the present study, MLM was used to determine if mind-wandering related variables predicted changes in negative affect over time following a negative mood induction. Additionally, MLM allows for the use of between-subject variables that are both time-variant (e.g., mind-wandering frequency) and time-invariant (e.g., BDI-II score).

Random effects and covariance structure. All statistical models were analyzed for both fixed and random effects. That is, all models were analyzed for the fixed effects of the predictor variables of interest while allowing for a random intercept at the participant level. Moreover, all models were constructed utilizing covariance structure assumptions standard to a Poisson distribution. This approach was taken as the distribution of negative affect ratings was best defined by a Poisson structure. Therefore, the default Variance Components covariance structure was used for all models.

Data exclusion. From the seventy-nine recruited participants, data from twelve participants was excluded from data analysis. This resulted in the data of sixty-seven participants (M age = 18.92, SD age = 3.34; 46 female) being used in subsequent analyses. The reasons for exclusion were as follows: two participants reported BDI-II scores of greater than 19 and were therefore removed from the study following the administration of preliminary questionnaires; one participant reported not understanding the working memory task, resulting in a performance score that was negative (i.e., a higher false alarm percentage than hit percentage);

nine participants reported no negative affect (i.e., a rating of 1) on the first prompt of the CRT task and reported no subsequent change in negative affect throughout the task. These latter participants were excluded as their reported negative affect is reflective of full recovery from the mood induction prior to the beginning of the CRT; this data would therefore be misrepresented if included in datasets reflecting repair and post-repair periods.

Baseline model construction. Three baseline models describing the pattern of negative affect ratings were constructed for three versions of the dataset. The *full model* contained data from all ten thought probes of the CRT task, the *repair model* contained data from the first five thought probes of the CRT task, and the *post-repair model* contained data from the latter five thought probes of the CRT task. In separating the repair and post-repair periods, mood recovery was defined at the group level as the thought probe at which negative affect had returned to its baseline level for two consecutive prompts. Baseline negative affect was operationalized as the negative affect reported on the mood check immediately prior to the mood induction (M = 2.69, SD = 1.23) and recovery to baseline was defined as a negative affect rating within one standard error (SE = 0.15) of baseline. Based on these parameters, the first five thought probes reflected the time period prior to group-level mood recovery.

Operationalizing key variables. The MLM analyses in the present study aimed to explain variance in negative affect (NA) reported at each time prompt (i.e., "How negative are you currently feeling?"; 1-9). Within the MLM framework, changes in NA over time were operationalized by the growth term (i.e., quadratic or linear) of NA. Therefore, predictor variables of interest (e.g., mind-wandering frequency) would be associated with changes in NA over time (e.g., negative mood *sustainment*) if statistically significant interactions were found between the predictor variable and a growth term of NA. Alternatively, a statistically significant predictor variable, without an interaction with an NA growth term, would be representative of a main effect of the predictor variable on the overall level of reported NA within the respective dataset (i.e., overall level of NA *across time*).

Predictor variables of interest included two time-variant variables, ratings of mind-wandering frequency (FREQ) and mind-wandering event content (EVENT), and two time-invariant variables, dysphoric symptomatology (BDI) and working memory capacity (WMC). FREQ and EVENT were operationalized as the ratings of mind-wandering frequency ("How much were you thinking about something other than the task?"; 1-9) and mind-wandering event content ("How much were you thinking about your personal event?"; 1-9) at each though probe, respectively. The personal event in the EVENT variable refers to the event chosen by the participant and used during the negative mood induction procedure. The content variable therefore reflected off-task thought content that was both past-oriented and negatively-valenced. Mean ratings for time-variant variables are provided in Table 1. BDI was operationalized as the score on the BDI-II, while WMC was operationalized as performance on the working memory task (i.e., hit percentage minus false alarm percentage). Descriptive statistics of time-invariant variables are provided in Table 2.

RESULTS

Manipulation Check

A manipulation check was performed to ensure a statistically significant increase in negative mood following the mood induction procedure (Ingram and Ritter, 2000). A paired t-test confirmed that the mood induction was successful ($t(66) = -4.018$, $p < .001$), as more negative affect was reported in the PANAS following the mood induction (M = 15.94, SD = 5.95) as compared to the PANAS immediately prior to the mood induction (M = 13.42, SD =

3.1). Ratings of negative affect on the mood check (i.e., “How negative are you currently feeling?”; 1-9) additionally reflected the success of the mood manipulation. A paired t-test revealed participants reported significantly greater negative affect ($t(66) = -9.04$, $p < .001$) following the mood induction (M = 4.63, SD = 1.93) as compared to immediately prior to the mood induction ($M = 2.69$, $SD = 1.23$).

Negative Affect Growth Models

Full model. In the full model, using a quadratic function to explain negative affect growth resulted in significantly better model fit in comparison with a linear growth function ($\chi 2$ (1) = 20.22, $p < .001$). In the present work, orthogonal polynomial estimates will be reported for all model comparisons when utilizing the full dataset. However, raw polynomial estimates are useful in explaining the direction of quadratic growth. In the full model, raw polynomial estimates indicated that linear growth of negative affect was negative ($\beta = -0.12$, $SE = .027$, $p < .001$) and quadratic growth of negative affect was positive ($\beta = 0.01$, $SE = .003$, $p < .001$). This pattern of negative affect growth, as predicted by the full model, is displayed in Figure 1. As shown, negative affect decreased until approximately the fifth thought probe, at which time it was approximately equal to baseline negative affect, before increasing over the remainder of the study.

Repair and post-repair models. In the repair ($\chi 2$ (1) = 2.56, $p = .110$) and post-repair ($\chi 2$ (1) = 0.65, $p = .421$) models, negative affect growth was better explained using a linear function, as the model including the quadratic growth term did not result in significantly greater model fit. In the repair model, negative affect was found to decrease over time ($\beta = -0.08$, $SE = .022$, $p < .001$), while negative affect was found to increase over time in the post-repair model ($\beta = 0.06$, $SE = .022$, $p = .008$).

Hypothesis 1: Mind-Wandering Frequency

Finalized results of model comparisons including the FREQ variable are reported in Table 3. Results for each model are summarized below. In Hypothesis 1, I predicted that mind-wandering frequency would explain unique variance in negative affect change over time (i.e., there would be a statistically significant interaction between FREQ and an NA growth term) within all three datasets. Specifically, I hypothesized that greater levels of mind-wandering frequency would be predictive of more positive change (i.e., increases) in negative affect over time. This hypothesis not supported in either the full or repair models, but was supported in the post-repair model.

Full model. Utilizing the full dataset, FREQ was not associated with either the quadratic (β = 0.44, *SE* = .230, *p* = .055) or linear (β = 0.04, *SE* = .253, *p* = .880) NA growth terms at a level of statistical significance. This result indicated that mind-wandering frequency did not explain unique variance in negative affect change *over time* during the entire task period. Therefore, these interaction terms (i.e., between FREQ and NA growth) were dropped from the full model.

In the main effect model, FREQ was a statistically significant predictor of NA (β = 0.03, *SE* = .012, *p* = .013). The direction of this result indicated that greater levels of mind-wandering frequency were associated with greater levels of NA, *across* the entire study period (Figure 2). Additionally, greater levels of both BDI (β = 0.14, *SE* = .051, *p* = .005) and WMC (β = 0.71, *SE* = .354, *p* = .045) predicted greater levels of NA across time. This finding suggests that dysphoric symptomatology and working memory capacity explained unique variance in negative affect relative to mind-wandering frequency, with greater levels of each variable predicting increased levels of reported negative affect.

Repair model. Utilizing data prior to group-level mood repair, FREQ was not associated with NA linear growth (β = 0.00, *SE* = .010, *p* = .888). This finding indicated that mind-wandering frequency did not explain unique variance in the sustainment of negative affect during the mood repair period. Therefore, the repair model for FREQ was fitted excluding the interaction term. A main effect for FREQ was found to be statistically significant (β = 0.04, *SE* = .017, *p* = .012), as greater mind-wandering frequency predicted greater levels of NA across the repair period (Figure 3). As with the full model, greater levels of both BDI (β = 0.10, *SE* = .049, *p* = .035) and WMC (β = 0.71, *SE* = .355, *p* = .045) predicted greater levels of NA across the repair period.

Post-repair model. Utilizing data following group-level mood repair, FREQ was found to be significantly associated with the linear growth term of NA (β = 0.02, *SE* = .008, *p* = .008). The direction of this result indicated that greater levels of mind-wandering frequency predicted a more positive linear trajectory of negative affect during the post-repair period (Figure 4). Once again, greater levels of BDI (β = 0.16, *SE* = .063, *p* = .010) predicted greater levels of NA across the post-repair period. However, WMC was not significantly associated with NA (β = 0.73, *SE* = .433, *p* = .093) and was therefore dropped form the post-repair model. This finding suggests that working memory capacity no longer explained unique variance in NA in the post-repair period. This may have been due to a decrease in the association between working memory capacity and negative affect over time or an increase in shared variance due to the significant interaction between mind-wandering frequency and linear growth of negative affect.

Hypothesis 2: Mind-Wandering Content

Finalized results of model comparisons including the EVENT variable are reported in Table 4. Results for each model are summarized below. In Hypothesis 2, I predicted that increased ratings of mind-wandering content reflecting participants' past-oriented, negative event would predict increased negative affect, but would not influence changes in negative affect over time. This hypothesis was fully supported in all three models. Therefore, all models were fitted and graphed with the interaction terms (i.e., between EVENT and NA growth) excluded.

Full model. Utilizing the full dataset, EVENT was a significant predictor of NA in the full model (β = 0.09, *SE* = .015, $p < .001$). However, the interaction between EVENT and both linear (β = 0.13, *SE* = .298, $p = .662$) and quadratic (β = -0.03, *SE* = .294, $p = .913$) growth of NA did not reach statistical significance. This result indicated that greater levels of mind-wandering about a past-oriented, negative event predicted greater negative affect levels over the complete task period, but did not explain unique variance in negative affect change over time (Figure 5). Additionally, greater levels of both BDI (β = 0.17, *SE* = .049, $p < .001$) and WMC (β = 0.92, *SE* = .334, $p = .006$) predicted greater levels of NA. This finding suggests that dysphoric symptomatology and working memory capacity explained unique variance in negative affect relative to mind-wandering content, with greater levels of each variable predicting increased levels of negative affect.

Repair model. Utilizing data prior to group-level mood repair, EVENT was a significant predictor of NA in the repair model (β = 0.08, *SE* = .019, $p < .001$). However, the interaction between EVENT and linear growth of NA did not reach statistical significance (β = 0.01, *SE* = .011, $p = .515$). This result indicated that greater levels of mind-wandering about the past-oriented, negative event predicted greater negative affect levels over the repair period, but did not explain unique variance in negative mood sustainment (Figure 6). As in the full model, greater levels of both BDI (β = 0.13, *SE* = .048, $p = .006$) and WMC (β = 0.97, *SE* = .335, $p = .004$) predicted greater levels of NA across the repair period.

Post-repair model. Utilizing data following group-level mood repair, EVENT was a significant predictor of NA in the post-repair model (β = 0.08, *SE* = .025, *p* = .002). However, the interaction between EVENT and linear growth of NA did not reach statistical significance (β = 0.00, *SE* = .013, *p* = .939). This result indicated that greater levels of mind-wandering about the past-oriented, negative event predicted greater negative affect levels over the post-repair period, but did not explain unique variance in negative affect change over time (Figure 7). Once again, greater levels of both BDI (β = 0.19, *SE* = .059, *p* = .001) and WMC (β = 0.90, *SE* = .408, *p* = .023) predicted greater levels of NA during the post-repair period.

Exploratory Analysis: Mind-Wandering Rate of Change

During the repair period, absolute levels of mind-wandering frequency did not explain unique variance in negative affect change over time. This result indicated that negative mood sustainment was equivalent between high and low levels of mind-wandering frequency. This finding was unexpected, as a plethora of previous work (Smallwood et al., 2007; Killingsworth & Gilbert, 2010; Smallwood & O'Connor, 2011) has replicated the finding that high levels of mind wandering frequency are associated with negative mood while low levels of mind-wandering frequency are associated with positive mood. However, the addition of a negative mood induction in the current study resulted in novel phenomenon within mind-wandering research; that is, during the repair period, negative affect is *decreasing* over time at the group level. Therefore, it is intriguing to explore the *growth of mind-wandering over time*, as an increasing linear trend in mind-wandering would be expected to operate against the decrease in negative affect that is occurring over the repair period. Because this affective dynamic (i.e., mood repair) has not been captured in previous studies of mind-wandering, it may be that negative affect change during this period is better predicted by a novel mind-wandering variable: rate of change.

An exploratory analysis was conducted, in which the rate of change in mind-wandering (SLOPE) was assessed for its association with negative affect change over time. SLOPE was calculated separately for each of the three datasets under investigation (i.e., full, repair, and post-repair; Table 2). For each dataset, a regression line was fitted to individual ratings of mind-wandering frequency during the respective time period. SLOPE was then operationalized as the slope coefficient of the regression line for each participant. Complete results of the model comparisons including the SLOPE variable are reported in Table 5. Results for each model are summarized below.

Full model. Utilizing the full dataset, SLOPE was significantly associated with the linear growth of NA in the full model (β = 3.29, *SE* = 1.52, *p* = .031). The direction of this result indicated that as the rate of change in mind-wandering became more positive (i.e., more positive slope coefficient), the linear growth of negative affect was predicted to increase (Figure 8). The interaction between SLOPE and the quadratic growth term of NA did not reach statistical significance (β = 0.30, *SE* = 1.56, *p* = .845). Additionally, greater levels of both BDI (β = 0.14, *SE* = .051, *p* = .005) and WMC (β = 0.88, *SE* = .352, *p* = .012) predicted greater levels of NA in the full model. This finding suggests that both dysphoric symptomatology and working memory capacity explained unique variance in negative affect relative to mind-wandering rate of change, with greater levels of each variable predicting greater overall levels of negative affect.

Repair model. Utilizing data prior to group-level mood repair, SLOPE predicted increased linear growth of NA in the repair model (β = 0.07, *SE* = .030, *p* = .018). This result indicated that a more positive rate of change in mind-wandering predicted a more positive linear trajectory of negative affect (Figure 9). As this effect occurred during the repair period, this finding suggests that the sustainment of previously generated negative mood is predicted by increases in the rate of mind-wandering over time. Once again, greater levels of both BDI (β = 0.10, *SE* = .049, *p* = .034) and WMC (β = 0.934, *SE* = .343, *p* = .007) predicted greater levels of NA in the repair model.

Post-repair model. Utilizing data prior to group-level mood repair, SLOPE did not significantly predict NA linear growth in the post-repair model (β = 0.01, *SE* = .030, *p* = .817). This finding indicated that rate of change in mind-wandering did not explain unique variance in negative affect change over the course of the post-repair period. Therefore, the post-repair model for SLOPE was fitted excluding the interaction term. The main effect of SLOPE was also found to not reach statistical significance (β = 0.10, *SE* = .094, *p* = .286), as mind-wandering rate of change failed to predict overall levels of negative affect during the post-repair period. Despite failing to reach statistical significance, SLOPE was left in the model to provide descriptive and graphical content (Figure 10). Although greater levels of BDI predicted greater levels of NA (β = 0.17, *SE* = .065, *p* = .010), WMC was not found to be associated with NA at a statistically significant level (β = 0.79, *SE* = .437, *p* = .071). Therefore, the WMC term was additionally dropped from the post-repair model.

DISCUSSION

The cardinal purpose of the present study was to determine the role of mind-wandering in the sustainment of negative mood. Utilizing a multilevel growth modeling (MLM) approach, it was predicted that the frequency with which one mind-wandered would be predictive of negative mood sustainment. In model terms, this would be reflected by a statistical interaction between mind-wandering frequency and a growth term (i.e., linear or quadratic) of negative affect. Such an interaction would indicate that the frequency with which one mind-wandered altered the *trajectory* of negative mood, during a period of mood repair. This result would be manifest in a cumulative difference in negative affect over time between high- and low-frequency mind-wanderers.

Contrary to the primary hypothesis, mind-wandering frequency during the mood repair period failed to predict the *sustainment* of negative mood. Instead, higher mind-wandering frequency during the mood-repair period predicted a greater level of negative affect *across time (*i.e., a greater overall level of negative affect), without altering the trajectory of negative affect *over time* (i.e., increased sustainment of negative affect). Although this result serves to replicate previous work that has observed a general association between high levels of mind-wandering frequency and negative mood (Smallwood et al., 2007; Killingsworth & Gilbert, 2010; Smallwood & O'Connor, 2011), the present findings offer an important caveat to this association. That is, during a period in which mood repair was ongoing – a previously generated negative mood was being attenuated – high and low levels of mind-wandering frequency did not differentiate between subsequent changes in the *sustainment* of one's negative mood state.

As with mind-wandering frequency, the content of one's mind-wandering predicted the overall level of negative affect, without impacting its trajectory over the mood repair period. Specifically, participants indicating mind-wandering content that was negative and past-focused reported more negative affect than did individuals reporting less of such content. This result was supportive of the secondary study hypothesis, replicating previous work that observed an association between past-oriented, negatively valenced thought content and higher levels of negative mood (Ottaviani & Couyoumdjian, 2013; Poerio et al., 2013; Ruby et al., 2013). Once again, however, mind-wandering content was not found to predict the *sustainment* of negative affect over the mood repair period, an association observed in prior research examining future-related, anxious thought content (Stawarczyk et al., 2013).

But *why* would the occurrence of mind-wandering be predictive in the generation of negative mood (Ruby et al., 2013, Stawarczyk et al., 2013), yet not predictive of negative mood sustainment? How then do we explain individual differences in the recovery from negative mood, especially considering that high levels of mind-wandering frequency are seemingly present during both the sustainment and attenuation of negative affect? Could there be an additional characteristic of mind-wandering that better predicts the sustainment or attenuation of negative mood, across levels of mind-wandering frequency?

These questions prompted the initiation of an exploratory analysis, in which the rate of change in mind-wandering frequency was examined in terms of its ability to explain changes in negative affect over time. Mind-wandering rate of change is differentiated from mind-wandering frequency, as it reflected the *trajectory of mind-wandering occurrence over time* as opposed to the absolute level of mind-wandering frequency. One can imagine that, within groups of both high and low mind-wandering frequency, a further delineation can be made between individuals whom are increasing or decreasing their rate of mind-wandering over time.

Mind-wandering rate of change was found to be a statistically significant predictor in both the full and repair models of linear negative affect growth, but did not approach significance in the post-repair model. This finding indicated that, across levels of absolute mind-wandering frequency, a more positive rate of change in mind-wandering was predictive of more positive linear growth of negative affect. Critically, because this association was found in the repair, but not post-repair dataset, this finding provides direct evidence that mind-wandering rate of change, as opposed to absolute level of mind-wandering frequency, is predictive of the sustainment of previously generated negative mood.

Based on the results of the exploratory analysis, I theorize that in the context of a task low in cognitive demand, a more negative rate of change in mind-wandering (i.e., decreases in mind-wandering over time) was reflective of an ongoing mood repair process. In contrast, a more positive rate of change in mind-wandering (i.e., increases in mind-wandering over time) was reflective of a mood-worsening process. It follows that, during the repair period, if an individual was experiencing an increasing rate of mind-wandering, it is likely their mood repair processing had ceased and they had already begun rebuilding their negative affect. Therefore, the longer into the task period during which an individual is decreasing the rate of their mind-wandering, the longer and potentially more effective would be their psychological process of mood-repair.

This interpretation requires the separation of two components of affective dynamics: speed and depth of mood recovery (Davidson, 1998). An individual increasing their rate of mind-wandering during the repair period may have an affective style wherein mood recovery is conducted at high speed and shallow depth. Alternatively, an individual decreasing their rate of mind-wandering during the repair period may have an affective style comprised of slow speed yet great depth of mood recovery. Depth of mood recovery is adaptive in the context of long-lasting situations low in cognitive demand, as it would be expected that mind-wandering frequency, and therefore negative affect, will increase as the situation progresses. Therefore, those with shallow depth of mood recovery (i.e., those with an increasing rate of mind-wandering during the repair period) would be predicted to rebuild negative affect on a foundation of negative mood that was not fully recovered.

This explanation is supported by the interaction between mind-wandering rate of change and the linear, but not quadratic growth term of negative affect (as seen in the SLOPE full model; graphically displayed in Figure 8). While the linear term is relatively indicative of negative affect change while the process of mood-repair remains ongoing, the quadratic term is more reflective of negative affect change following the cessation of one's mood repair process. The likelihood of this interpretation is additionally encouraged by the lack of an association between mind-wandering rate of change and negative affect change in the post-repair period of the task. This is because remaining levels of previously generated negative mood are expected to be more fully mitigated in the post-repair dataset. Therefore, an increased rate of mind-wandering during the post-repair period would not be expected to explain variance in negative affect change over time, as the rate at which mind-wandering generates negative affect would be less dependent on the amount of previously generated negative mood that was unrecovered (i.e., more purely based on the quadratic growth term, rather than the linear term, of negative affect in the full model).

The present study has several implications for future research on both mind-wandering and affective processes. First, the finding that mind-wandering rate of change predicted negative mood sustainment encourages the use of mind-wandering rate of change as a study variable in future research. As previous work suggests, simply knowing an individual's mean level of mind-wandering frequency or content over a given study period is not enough to conceptualize the trajectory of their negative affect (Ottaviani & Couyoumdjian, 2013; Poerio et al., 2013). Frequency, content, and growth data may need to be combined to produce a more complete understanding of the effect of mind-wandering on changes in negative mood over time.

In terms of methodological considerations, an approximation can be made using study data as to the length of time required to recover from a negative mood generated using a standard mood induction procedure (Ingram & Ritter, 2000). Based on group level study data, negative mood returns to baseline levels at the fifth time prompt; this equates to approximately 10 minutes following the end of the mood induction procedure. Therefore, studies utilizing similar procedures should be aware that study tasks administered after 10 minutes following a mood induction may no longer be influenced by previously generated negative mood.

Additionally, the current study shows that a basic, low cognitive demand choice reaction time (CRT) task may have a powerful negative effect on participant mood. In the present study, group levels of negative affect at the beginning of the CRT task (M = 3.82), approximated the level of negative affect reported at the end of the CRT task (M = 3.46), following an intermediate recovery in negative affect levels. Researchers should therefore be aware that administering a CRT task low in cognitive demand may have mood induction effects of its own. This finding calls for caution in the use of study tasks or questionnaires immediately following CRT task administration.

Several clinical disorders are marked by the abnormal sustainment of negative mood and therefore potentially affected by the results of this study. Pathological negative mood sustainment can take place over the course of minutes (e.g., panic attacks) or the negative mood may last for weeks at a time (e.g., major depressive disorder). For the first time, the present study provides evidence for the role of mind-wandering in the perpetuation of previously generated negative mood states. It is therefore possible that mind-wandering rate of change plays an important role in both the failure to completely recover from a previous negative event, while mind-wandering frequency predicts the perpetuation of further negative affect on top of unrecovered negative mood.

For both patients and healthy individuals, reducing the rate of off-task thought after the occurrence of negative events may allow for a more complete attenuation of derived negative mood. Certainly, the present results provide further support for behavioral activation (BA) as a therapeutic strategy, as research has indicated BA decreases the frequency of off-task thought (Carver & White, 1994). Additionally, mindfulness-based practices (Kabat-Zinn, 2003) may also serve to prevent increases in the rate of mind-wandering during critical periods (e.g., following a negative event). However, the present study suggests that some level of mind-wandering following a negative experience is *adaptive* in nature, as the complete, immediate cessation of mind-wandering may prevent full recovery from a previously generated negative mood state. This may be especially true for environmental contexts in which the ability to engage in stimulating and social behaviors is intrinsically limited (e.g., school or work). Clinical practice should therefore *normalize* the tendency for clients to mind-wander following the occurrence of a negative event, instead placing an emphasis on the length of time that mind-wandering should occur and the trajectory of its growth over time. This implication represents a dramatic shift from the majority of clinical orientations, which suggest ruminative thought content concerning past, negative events is globally and intrinsically pathological.

The primary limitation of the current study was a limited sample size. Increasing sample size may have allowed for more power in differentiating the effects of mind-wandering frequency between repair and post-repair periods. Furthermore, an expanded sample may increase power in the detection of interactions between trait-level moderators (i.e., dysphoric symptomatology and working memory capacity) and the effect of mind-wandering variables.

Additionally, a disproportional amount of female (N = 46) as compared to male (N = 21) participants limited the ability to conduct analyses of gender differences. These limitations are being correctly presently, as the collection of an increased sample is already underway.

A second limitation of the study were the relatively low ratings of dysphoric symptomatology as rated on the BDI-II (M = 8.6). This limited range in dysphoria may have impacted the ability to detect differences in negative mood sustainment between individuals with high and low levels of dysphoric symptomatology. However, greater dysphoric symptomatology was associated with greater overall levels of negative affect in all three datasets. This provides evidence for a future proposal in which clinical levels of depressive symptomatology can be investigated at the group level, with the prediction that major depressive disorder may interact with mind-wandering rate of change in the sustainment of negative affect.

Conclusion

When James' "stream of consciousness" (1890) is dichotomized by its on- or off-task nature, powerful predictions can be made concerning the mood of the individual engaging in said stream (Killingsworth & Gilbert, 2010). The present study advances this work by illuminating a specific role for the occurrence of off-task thought in the sustainment of previously generated negative mood. Mind-wandering rate of change (i.e., the degree to which mind-wandering increased or decreased in frequency over time) was a significant predictor of the sustainment of negative mood. Specifically, when the rate of mind-wandering increased over time, the sustainment of negative mood following a mood induction was increased. By comparison, overall levels of mind-wandering frequency did not explain variance in the sustainment (i.e., trajectory) of negative mood. I therefore theorized that, just as mind-wandering frequency has been used as an indicator of global mood state (Smallwood et al., 2007; Killingsworth & Gilbert, 2010; Smallwood & O'Connor, 2011), mind-wandering rate of change may be an indicator of one's ongoing affective process (e.g., mood repair vs. mood-worsening). Of course, mind-wandering must be considered within its environmental and human context to allow for conclusions concerning the affective process under investigation. Environmental factors (e.g., low cognitive demand, social isolation) and trait-level variables (e.g., dysphoric and anxious symptomatology) should be targeted as potential instigators of maladaptive rates of change in mind-wandering over time.

References

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders: DSM-5. Washington, D.C: American Psychiatric Association.

Baird, B., Smallwood, J., Mrazek, M. D., Kam, J. W., Franklin, M. S., & Schooler, J. W. (2012). Inspired by distraction mind-wandering facilitates creative incubation. *Psychological Science*, 0956797612446024.

Baird, B., Smallwood, J., & Schooler, J. W. (2011). Back to the future: Autobiographical planning and the functionality of mind-wandering. *Consciousness and Cognition*, *20*(4), 1604-1611.

Beck, J. S. (1979). *Cognitive therapy*. John Wiley & Sons, Inc.

Beck, A.T., Steer, R.A., & Brown, G.K. (1996). Manual for the Beck Depression Inventory-II. San Antonio, TX: Psychological Corporation.

Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS Scales. *Journal of personality and social psychology*, *67*(2), 319.

Christoff, K., Gordon, A. M., Smallwood, J., Smith, R., & Schooler, J. W. (2009). Experience sampling during fMRI reveals default network and executive system contributions to mind-wandering. *Proceedings of the National Academy of Sciences*, *106*(21), 8719-8724.

Curran, P. J., Obeidat, K., & Losardo, D. (2010). Twelve frequently asked questions about growth curve modeling. *Journal of Cognition and Development*, *11*(2), 121-136.

Davidson, R. J. (1998). Affective style and affective disorders: Perspectives from affective neuroscience. *Cognition & Emotion*, *12*(3), 307-330.

Duncan, T. E., & Duncan, S. C. (2004). An introduction to latent growth curve modeling. *Behavior Therapy*, *35*(2), 333-363.

Eastwood, J. D., Frischen, A., Fenske, M. J., & Smilek, D. (2012). The unengaged mind defining boredom in terms of attention. *Perspectives on Psychological Science*, *7*(5), 482-495.

Eich, E., & Macaulay, D. (2000). Fundamental factors in mood-dependent memory. *Feeling and Thinking: The role of affect in social cognition*, 109-130.

Eich, E., & Metcalfe, J. (1989). Mood dependent memory for internal versus external events. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*(3), 443.

Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions. *American Psychologist*,*56*(3), 218.

Ingram, R. E., & Ritter, J. (2000). Vulnerability to depression: Cognitive reactivity and parental bonding in high-risk individuals. *Journal of Abnormal Psychology*, *109*(4), 588.

Jaeggi, S. M., Buschkuehl, M., Perrig, W. J., & Meier, B. (2010). The concurrent validity of the N-back task as a working memory measure. *Memory*, *18*(4), 394-412.

James, W. (1890). The principles of psychology (Vol. 1). *New York: Holt*.

Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: past, present, and future. *Clinical Psychology: Science and Practice*, *10*(2), 144-156.

Kane, M. J., Brown, L. H., McVay, J. C., Silvia, P. J., Myin-Germeys, I., & Kwapil, T. R. (2007). For whom the mind wanders, and when an experience-sampling study of working memory and executive control in daily life. *Psychological Science*, *18*(7), 614-621. doi: 10.1111/j.1467-9280.2007.01948.x

Killingsworth, M. A., & Gilbert, D. T. (2010). A wandering mind is an unhappy mind. *Science*, *330*(6006), 932-932. doi: 10.1126/science.1192439

Mason, M. F., Bar, M., & Macrae, C. N. (2008). Exploring the past and impending future in the here and now: mind-wandering in the default state. *Cognitive Sciences*, *3*, 1-19.

McVay, J. C., & Kane, M. J. (2012). Drifting from slow to “d'oh!”: Working memory capacity and mind-wandering predict extreme reaction times and executive control errors. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *38*(3), 525.

McVay, J. C., Kane, M. J., & Kwapil, T. R. (2009). Tracking the train of thought from the laboratory into everyday life: an experience-sampling study of mind-wandering across controlled and ecological contexts. *Psychonomic Bulletin & Review*, *16*(5), 857-863. doi: 10.3758/PBR.16.5.857

Mikulincer, M. (1989). Cognitive interference and learned helplessness: The effects of off-task cognitions on performance following unsolvable problems. *Journal of Personality and Social Psychology*, *57*(1), 129.

Ottaviani, C., & Couyoumdjian, A. (2013). Pros and cons of a wandering mind: a prospective study. *Frontiers in Psychology*, *4*.

Ottaviani, C., Shapiro, D., & Couyoumdjian, A. (2013). Flexibility as the key for somatic health: from mind-wandering to perseverative cognition. *Biological Psychology*, *94*(1), 38-43.

Pennebaker, J. W. (1997). Writing about emotional experiences as a therapeutic process. *Psychological Science*, *8*(3), 162-166.

Poerio, G. L., Totterdell, P., & Miles, E. (2013). Mind-wandering and negative mood: Does one thing really lead to another? *Consciousness and Cognition*, *22*(4), 1412-1421.

Rapport, M. D., & Kelly, K. L. (1991). Psychostimulant effects on learning and cognitive function: Findings and implications for children with attention deficit hyperactivity disorder. *Clinical Psychology Review*, *11*(1), 61-92.

Ruby, F. J., Smallwood, J., Engen, H., & Singer, T. (2013). How self-generated thought shapes mood—the relation between mind-wandering and mood depends on the socio-temporal content of thoughts. *PLoS One*, *8*(10), e77554. doi: 10.1371/journal.pone.0077554

Sayette, M. A., Reichle, E. D., & Schooler, J. W. (2009). Lost in the sauce: The effects of alcohol on mind-wandering. *Psychological Science*, *20*(6), 747-752. doi: 10.1111/j.1467-9280.2009.02351.x

Smallwood, J. (2013). Distinguishing how from why the mind wanders: a process–occurrence framework for self-generated mental activity. *Psychological Bulletin*, *139*(3), 519.

Smallwood, J., & Andrews-Hanna, J. (2013). Not all minds that wander are lost: the importance of a balanced perspective on the mind-wandering state. *Frontiers in Psychology*, *4*.

Smallwood, J., McSpadden, M., & Schooler, J. W. (2007). The lights are on but no one's home: Meta-awareness and the decoupling of attention when the mind wanders. *Psychonomic Bulletin & Review*, *14*(3), 527-533.

Smallwood, J., & O'Connor, R. C. (2011). Imprisoned by the past: unhappy moods lead to a retrospective bias to mind-wandering. *Cognition & Emotion*,*25*(8), 1481-1490.

Smallwood, J., O'Connor, R. C., Sudbery, M. V., & Obonsawin, M. (2007). Mind-wandering and dysphoria. *Cognition and Emotion*, *21*(4), 816-842.

Smallwood, J., & Schooler, J. W. (2014). The Science of Mind-wandering: Empirically Navigating the Stream of Consciousness. *Annual Review of Psychology*. doi: 10.1146/annurev-psych-010814-015331

Smilek, D., Carriere, J. S., & Cheyne, J. A. (2010). Out of mind, out of sight eye blinking as indicator and embodiment of mind-wandering. *Psychological Science*, *21*(6), 786-789.

Spasojević, J., & Alloy, L. B. (2001). Rumination as a common mechanism relating depressive risk factors to depression. *Emotion*, *1*(1), 25.

Stawarczyk, D., Majerus, S., & D'Argembeau, A. (2013). Concern-induced negative affect is associated with the occurrence and content of mind-wandering. *Consciousness and Cognition*, *22*(2), 442-448.

Tusche, A., Smallwood, J., Bernhardt, B. C., & Singer, T. (2014). Classifying the wandering mind: revealing the affective content of thoughts during task-free rest periods. *Neuroimage*, *97*, 107-116.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063-1070.

Wilson, T. D., Reinhard, D. A., Westgate, E. C., Gilbert, D. T., Ellerbeck, N., Hahn, C., ... & Shaked, A. (2014). Just think: The challenges of the disengaged mind. *Science*, *345*(6192), 75-77.

Table 1. Mean Thought Probe Ratings

Thought Probe	1	2	3	4	5	6	7	8	9	10
Positive Affect	4.82	5.04	5.36	5.31	5.25	4.99	4.81	4.81	4.67	4.51
***Negative Affect**	3.82	3.28	2.85	2.81	2.79	2.73	3.03	3.28	3.37	3.46
***MW Frequency**	3.15	3.24	4.03	4.27	4.28	4.66	4.94	5.04	4.82	5.06
***MW Event**	2.75	2.10	1.91	1.76	1.75	1.63	1.78	1.73	1.58	1.55
MW Other	3.36	2.87	3.40	3.31	2.84	3.16	3.01	3.16	2.94	3.61
MW Self	2.63	2.90	3.01	3.40	3.61	3.58	3.78	3.63	4.13	3.52
MW Past	3.03	2.28	2.10	2.22	2.07	2.09	2.18	2.24	2.24	2.40
MW Future	2.34	2.52	3.25	3.73	3.70	4.16	4.46	3.99	4.13	4.30
Positive Thoughts	3.91	4.67	5.15	5.16	4.97	5.03	4.88	4.69	4.87	4.54
Negative Thoughts	3.90	3.04	2.91	2.51	2.78	2.69	3.01	3.12	3.28	3.61

*Indicates variables of interest to the present study. Other means are provided for convenience.

Table 2. Trait-Level Participant Variables

	Age	BDI	WMC	SLOPE (Full)	SLOPE (Repair)	SLOPE (Post-Repair)
Minimum	18	0	0.14	-0.47	-1.30	-1.80
Median	18	8	0.58	0.19	0.30	0.00
Maximum	32	18	0.85	0.96	1.90	2.10
Mean	18.92	8.60	0.58	0.22	0.33	0.07
SD	3.34	4.02	0.15	0.36	0.72	0.68
N	66*	67	67	67	67	67

*One participant did not provide age information

Table 3. Model Comparisons of Mind-Wandering Frequency

	Full Estimate (S.E.)	Repair Estimate (S.E.)	Post-Repair Estimate (S.E.)
(Intercept)	0.52*	0.69**	1.41***
	(.212)	(.214)	(.365)
Time-Linear	-0.50	-0.10***	-0.07
	(.578)	(.023)	(.050)
Time-Quad	2.66***	.	.
	(.552)	.	.
FREQ	0.03*	0.04*	-0.14*
	(.012)	(.017)	(.064)
BDI	0.14**	0.10*	0.16**
	(.051)	(.049)	(.063)
WMC	0.71*	0.71*	.
	(.354)	(.355)	.
Time-Linear x FREQ	.	.	0.02**
	.	.	(.009)
N	67	67	67
# of Obs.	670	335	335

* $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.001$

Table 4. Model Comparisons of Mind-Wandering Content

	Full Estimate (S.E.)	Repair Estimate (S.E.)	Post-Repair Estimate (S.E.)
(Intercept)	0.36	0.46*	-0.03
	(.204)	(.216)	(.297)
Time-Linear	0.60	-0.06**	0.06**
	(.550)	(.022)	(.022)
Time-Quad	2.15***	.	.
	(.553)	.	.
EVENT	0.09***	0.08***	0.08**
	(.015)	(.019)	(.025)
BDI	0.17***	0.13**	0.19**
	(.049)	(.048)	(.059)
WMC	0.92**	0.97**	0.90*
	(.334)	(.335)	(.408)
N	67	67	67
# of Obs.	670	335	335

* $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.001$

Table 5. Model Comparisons of Mind-Wandering Rate of Change

	Full Estimate (S.E.)	Repair Estimate (S.E.)	Post-Repair Estimate (S.E.)
(Intercept)	0.49*	0.71**	0.63***
	(.216)	(.215)	(.167)
Time-Linear	-0.80	-0.11***	0.06**
	(.661)	(.025)	(.022)
Time-Quad	2.40***	.	.
	(.672)	.	.
SLOPE	0.27	-0.03	0.10
	(.142)	(.087)	(.094)
BDI	0.14**	0.10*	0.17**
	(.051)	(.049)	(.065)
WMC	0.88*	0.93**	.
	(.352)	(.343)	.
Time-Linear x SLOPE	3.31*	0.07*	.
	(1.53)	(.030)	.
Time-Quad x SLOPE	0.30	.	.
	(1.56)	.	.
N	67	67	67
# of Obs.	670	335	335

* p ≤0.05 ** p ≤0.01 *** p ≤0.001

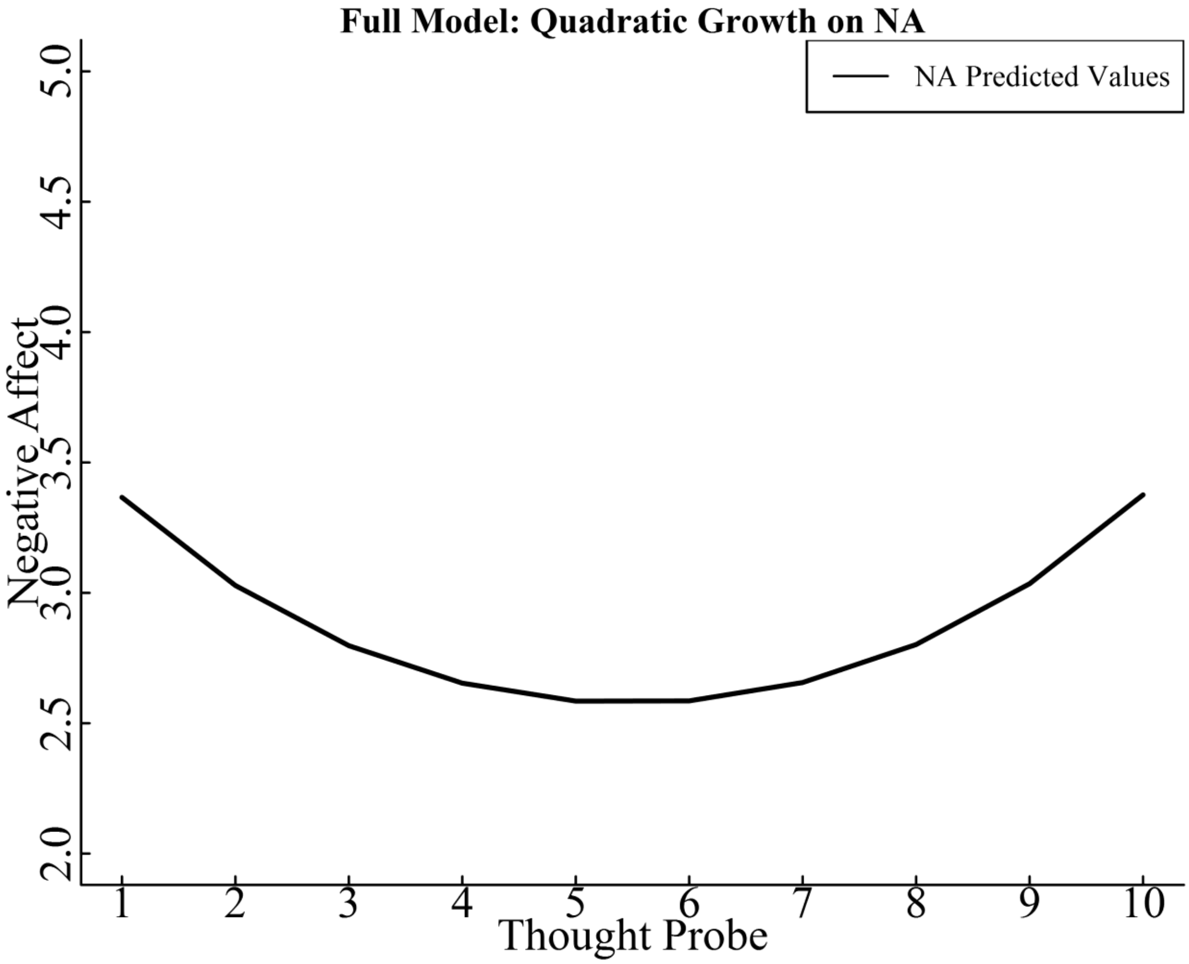


Figure 1. Effect of quadratic function on negative affect change over time. Line represents predicted values of negative affect as a quadratic function of time.

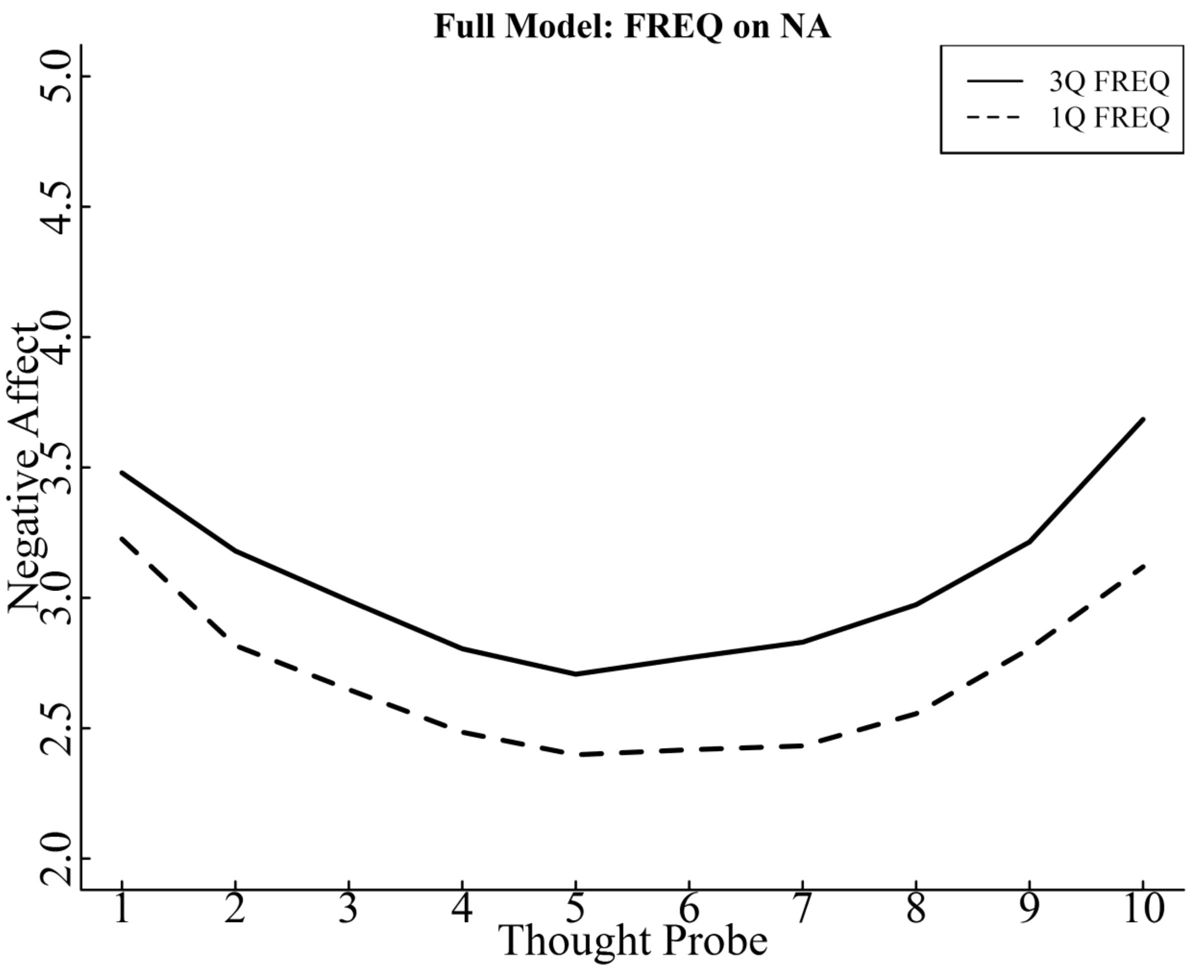


Figure 2. Effect of mind-wandering frequency (FREQ) on negative affect using the full dataset. Lines represent third and first quartile metrics for the variable of interest.

3Q [Time, FREQ] = [1, 4.00]; [2, 5.00]; [3, 6.00]; [4, 6.00]; [5, 6.00]; [6, 7.00]; [7, 7.00]; [8, 7.00]; [9, 7.00]; [10, 8.00]

1Q [Time, FREQ] = [1, 1.50]; [2, 1.00]; [3, 2.00]; [4, 2.00]; [5, 2.00]; [6, 2.50]; [7, 2.00]; [8, 2.00]; [9, 2.50]; [10, 2.50]

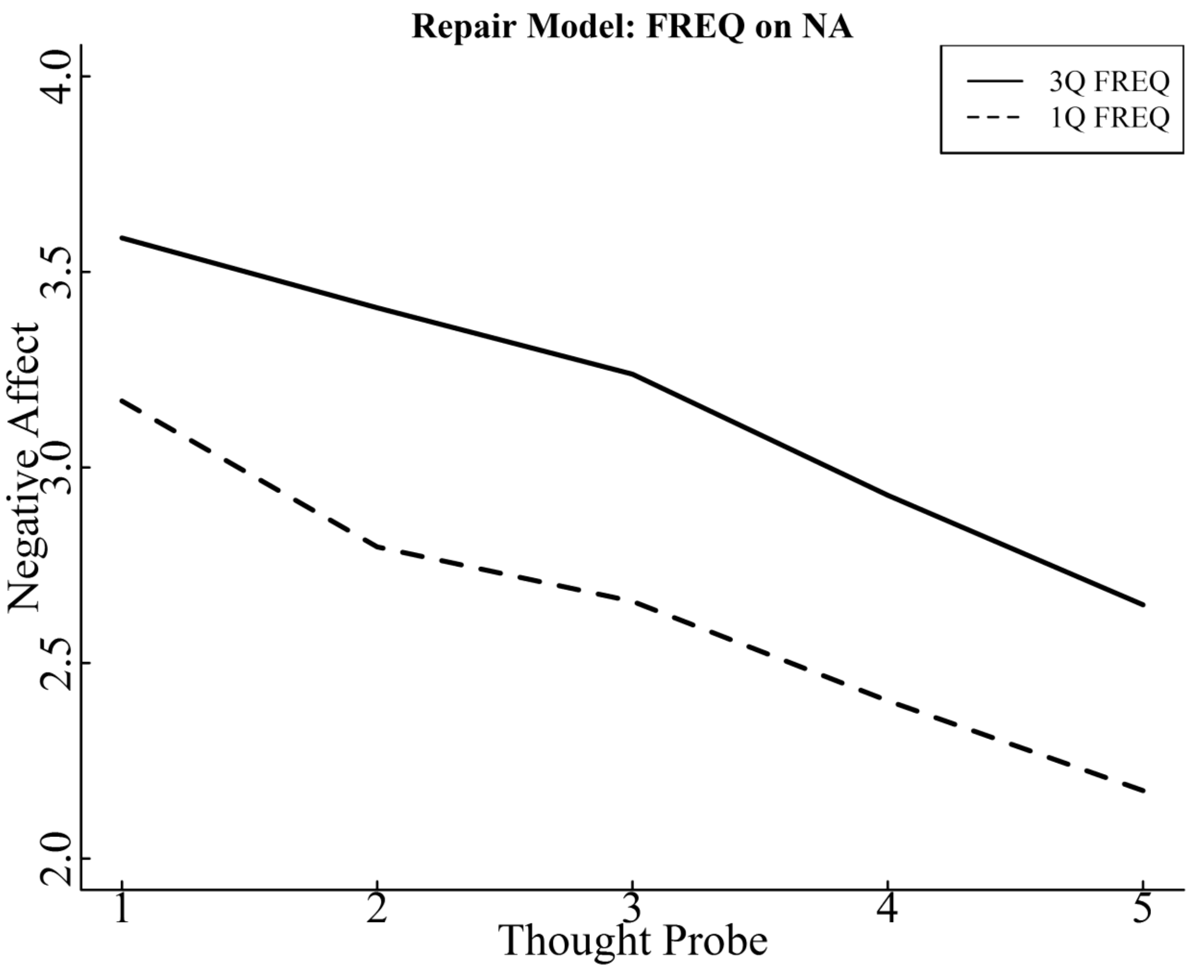


Figure 3. Effect of mind-wandering frequency (FREQ) on negative affect using the repair dataset. Lines represent third and first quartile metrics for the variable of interest.

3Q [Time, FREQ] = [1, 4.00]; [2, 5.00]; [3, 6.00]; [4, 6.00]; [5, 6.00]

1Q [Time, FREQ] = [1, 1.50]; [2, 1.00]; [3, 2.00]; [4, 2.00]; [5, 2.00]

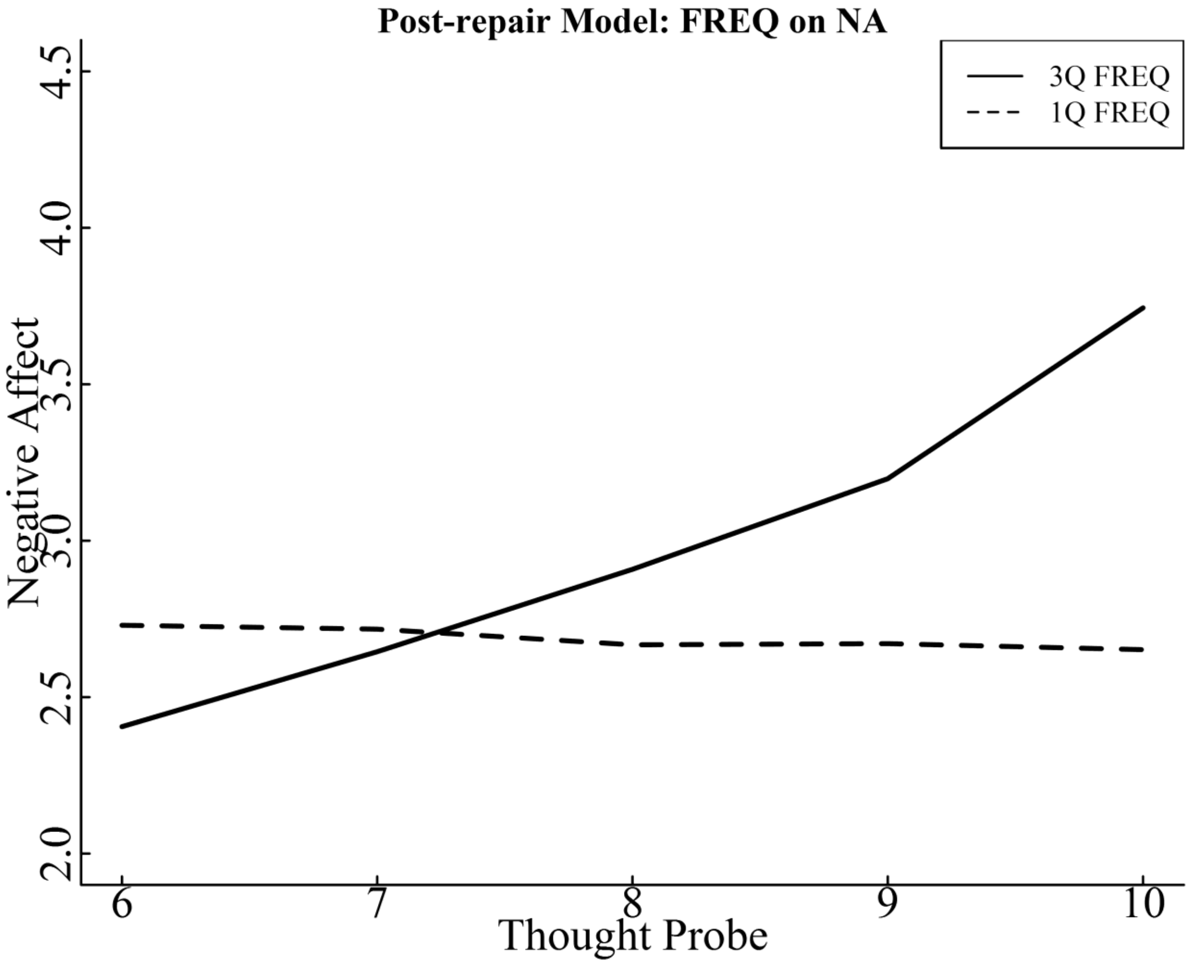


Figure 4. Effect of mind-wandering frequency (FREQ) on negative affect change over time using the post-repair dataset. Lines represent third and first quartile metrics for the variable of interest.

3Q [Time, FREQ] = [6, 7.00]; [7, 7.00]; [8, 7.00]; [9, 7.00]; [10, 8.00]

1Q [Time, FREQ] = [6, 2.50]; [7, 2.00]; [8, 2.00]; [9, 2.50]; [10, 2.50]

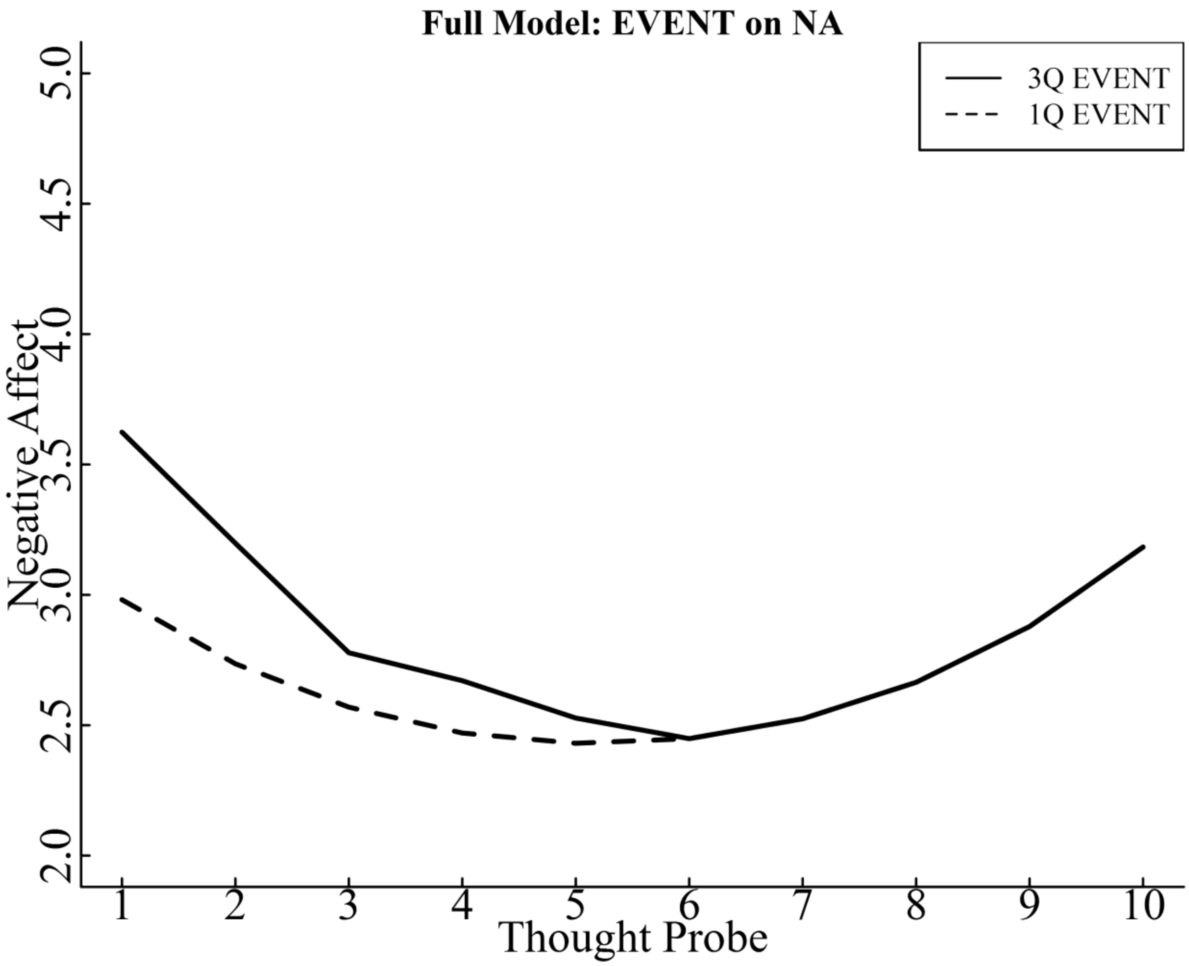


Figure 5. Effect of mind-wandering content (EVENT) on negative affect using the full dataset. Lines represent third and first quartile metrics for the variable of interest.

3Q [Time, EVENT] = [1, 3.50]; [2, 3.00]; [3, 2.00]; [4, 2.00]; [5, 1.50]; [6, 1.00]; [7, 1.00]; [8, 1.00]; [9, 1.00]; [10, 1.00]

1Q [Time, EVENT] = [1, 1.00]; [2, 1.00]; [3, 1.00]; [4, 1.00]; [5, 1.00]; [6, 1.00]; [7, 1.00]; [8, 1.00]; [9, 1.00]; [10, 1.00]

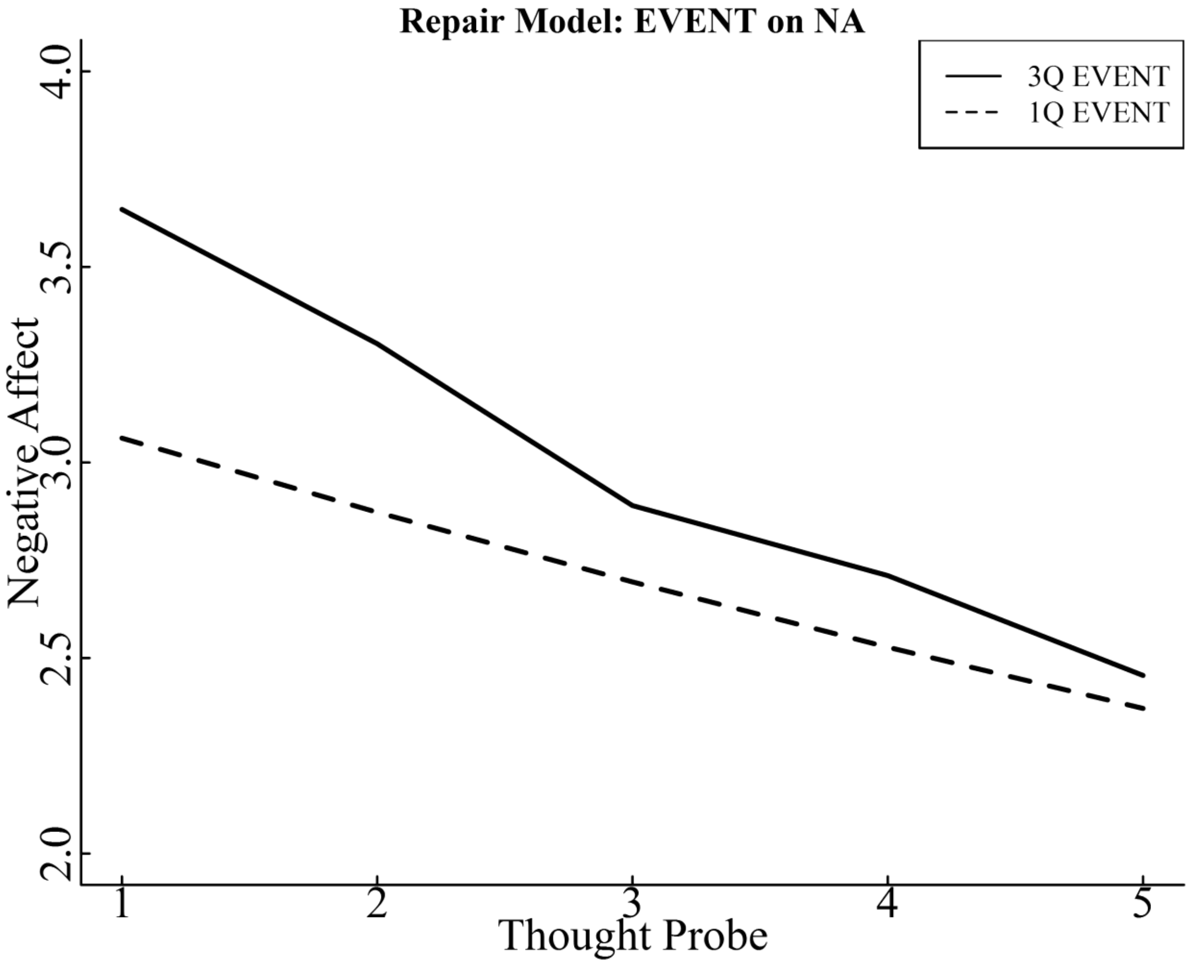


Figure 6. Effect of mind-wandering content (EVENT) on negative affect using the repair dataset. Lines represent third and first quartile metrics for the variable of interest.

3Q [Time, EVENT] = [1, 3.50]; [2, 3.00]; [3, 2.00]; [4, 2.00]; [5, 1.50]

1Q [Time, EVENT] = [1, 1.00]; [2, 1.00]; [3, 1.00]; [4, 1.00]; [5, 1.00]

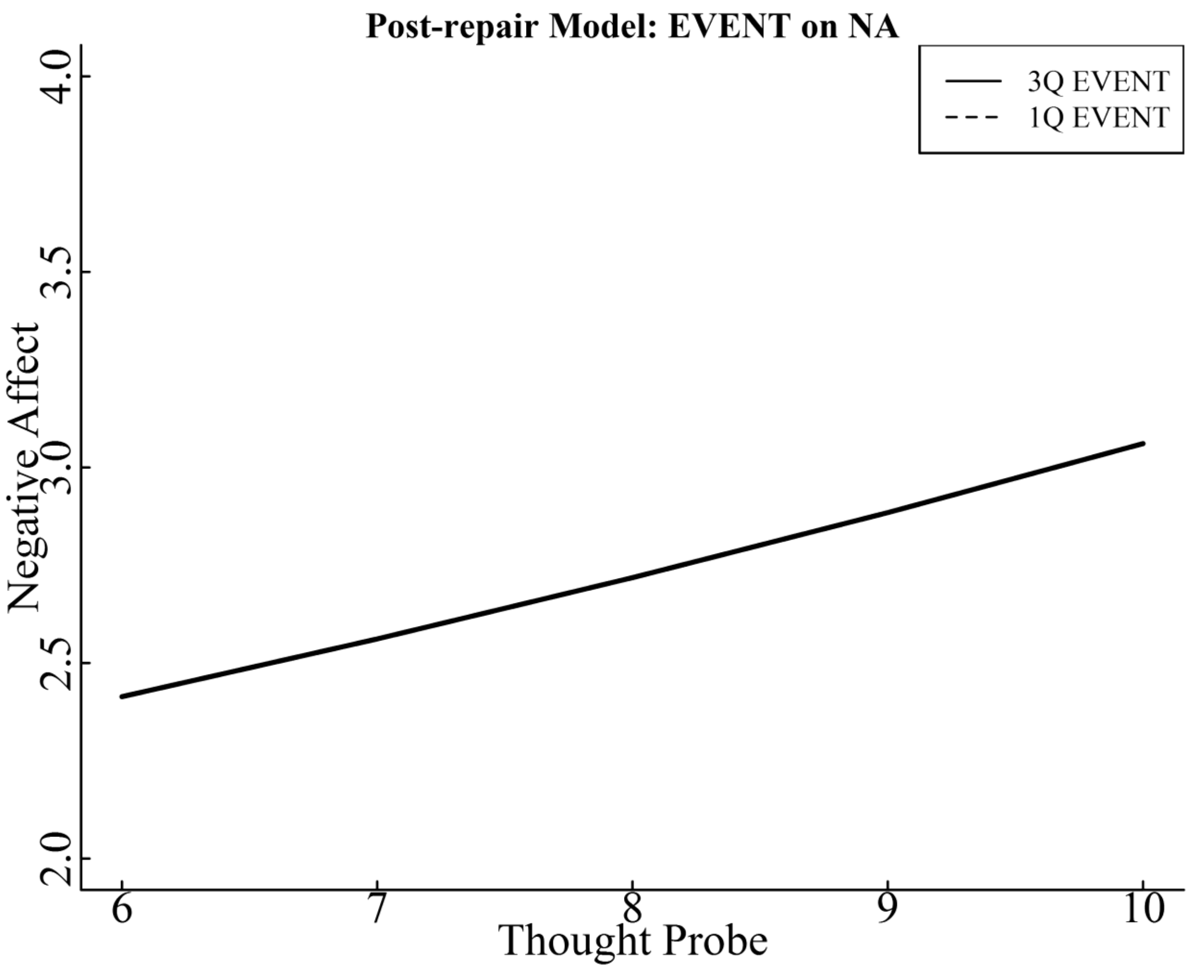


Figure 7. Effect of mind-wandering content (EVENT) on negative affect using the post-repair dataset. Lines represent third and first quartile metrics for the variable of interest. Note that third and first quartile metrics are identical for EVENT in the post dataset.

3Q [Time, EVENT] = [6, 1.00]; [7, 1.00]; [8, 1.00]; [9, 1.00]; [10, 1.00]

1Q [Time, EVENT] = [6, 1.00]; [7, 1.00]; [8, 1.00]; [9, 1.00]; [10, 1.00]

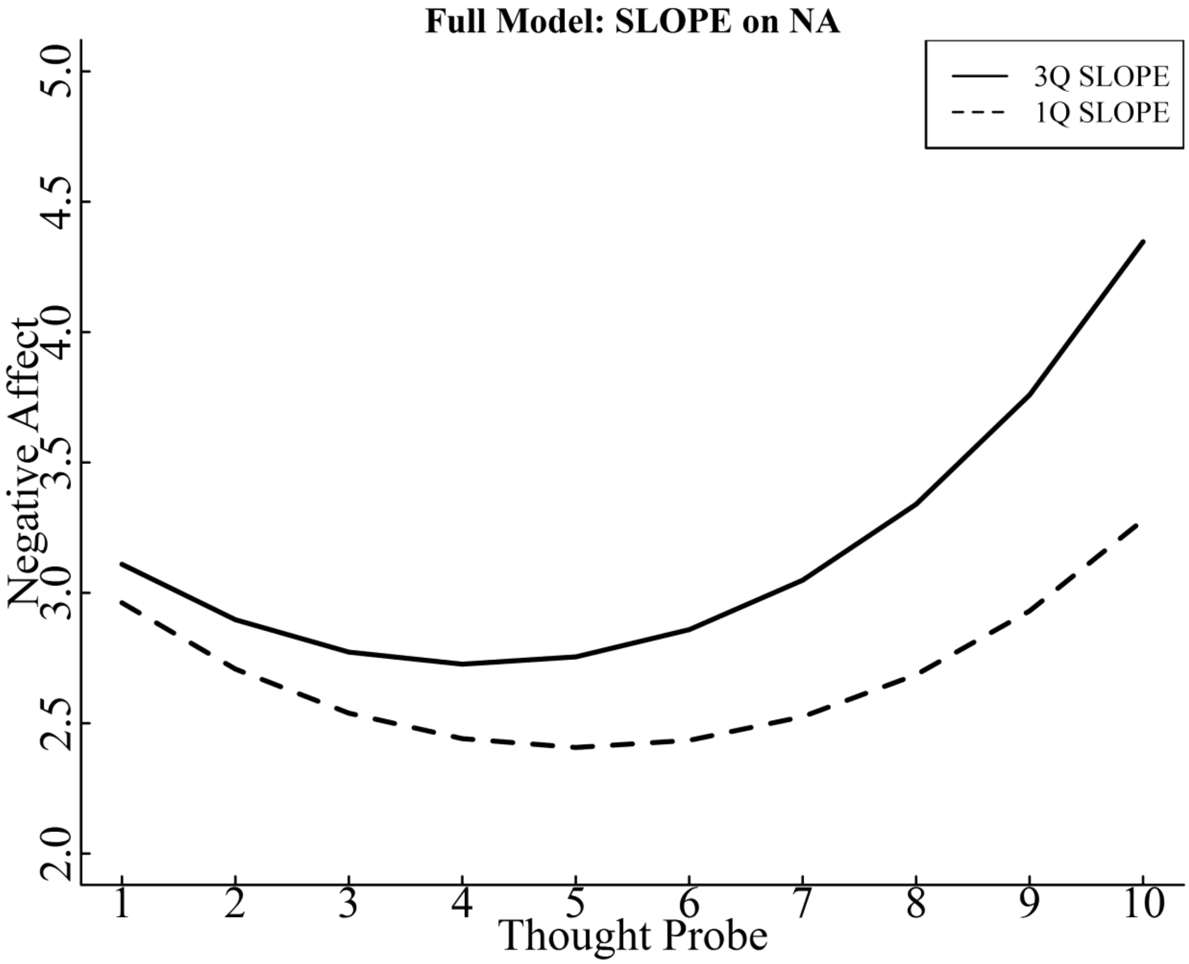


Figure 8. Effect of mind-wandering rate of change (SLOPE) on negative affect change over time using the full dataset. Lines represent third and first quartile metrics for the variable of interest.

3Q SLOPE = 0.473

1Q SLOPE = -0.073

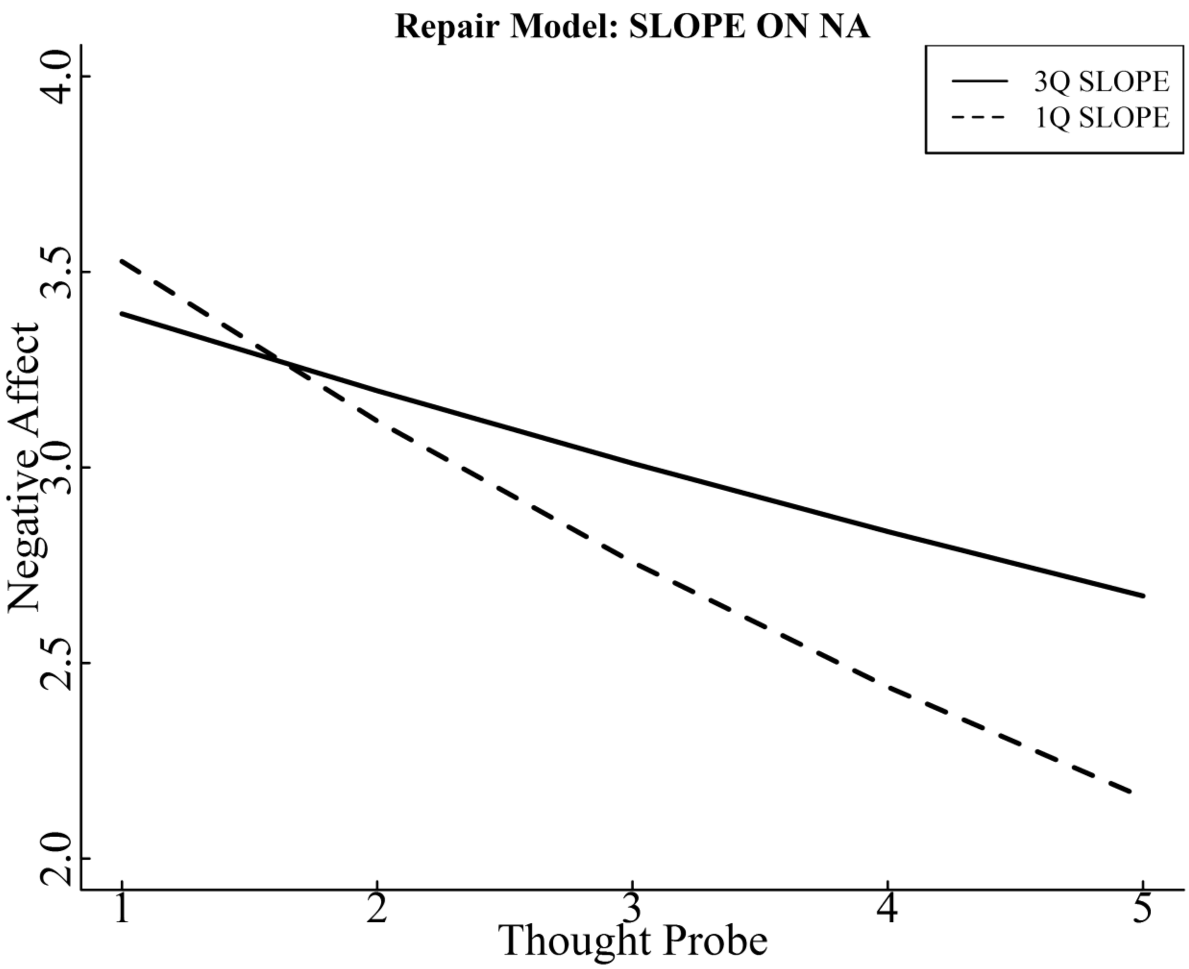


Figure 9. Effect of mind-wandering rate of change (SLOPE) on negative affect change over time using the repair dataset. Lines represent third and first quartile metrics for the variable of interest.

3Q SLOPE = 0.70

1Q SLOPE = -0.20

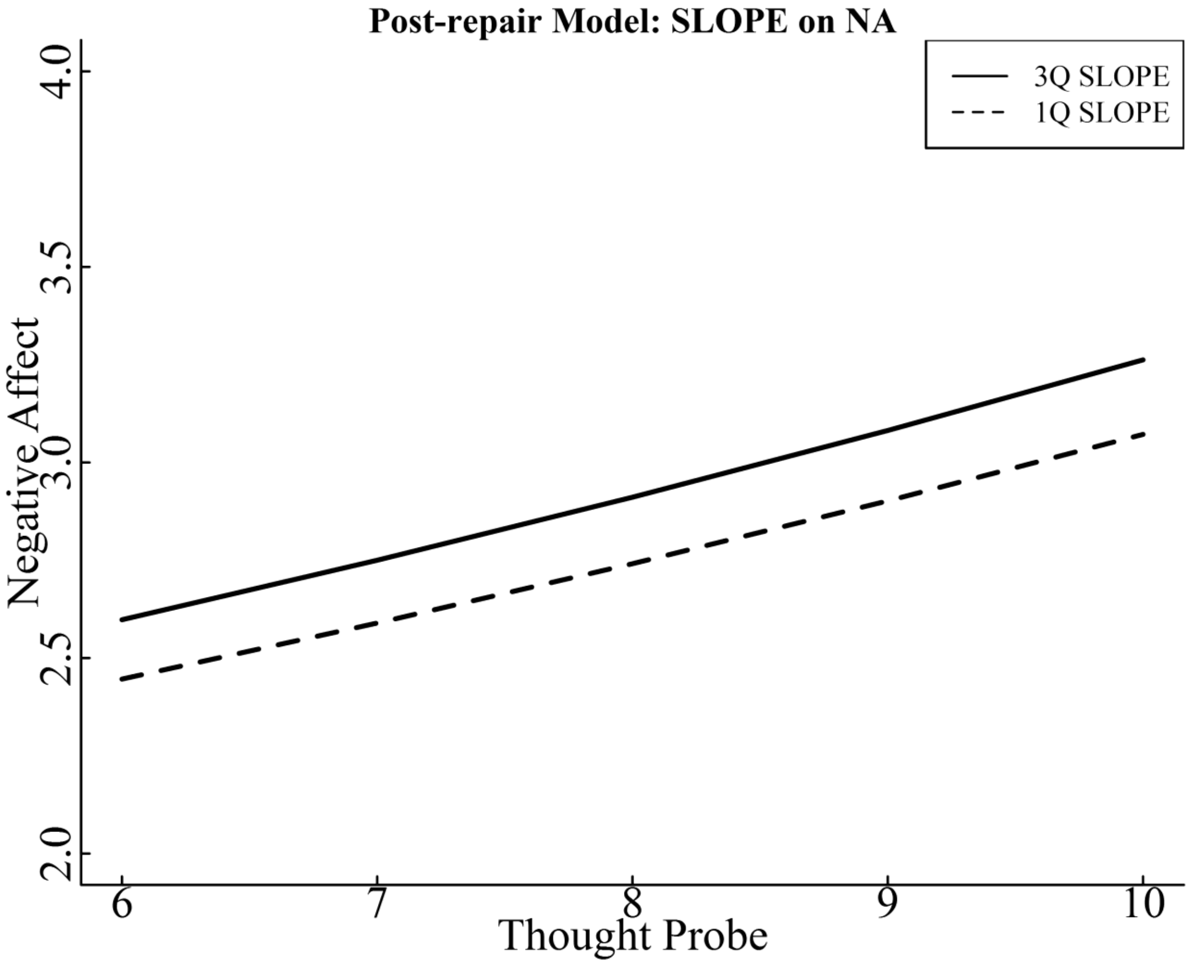
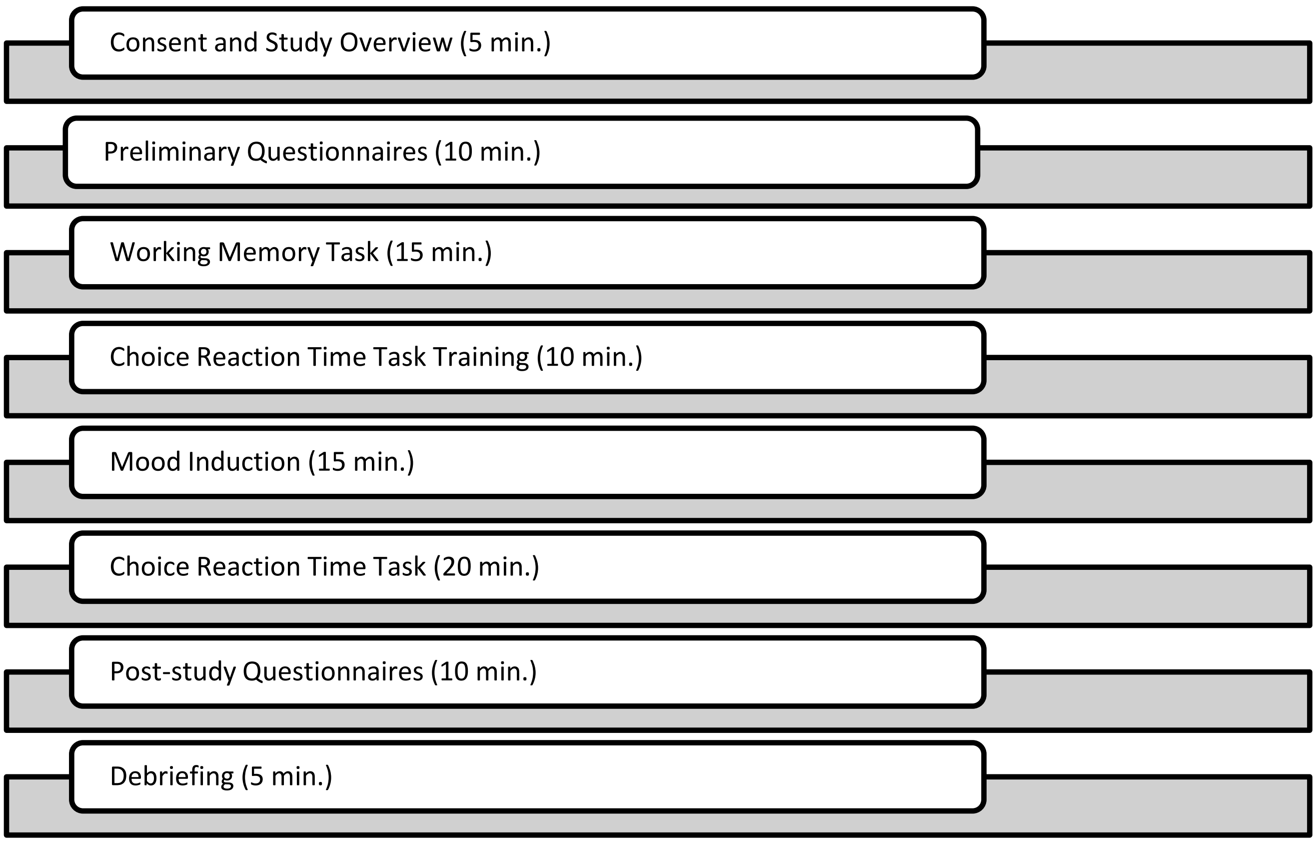


Figure 10. Effect of mind-wandering rate of change (SLOPE) on negative affect using the post-repair dataset. Lines represent third and first quartile metrics for the variable of interest.

3Q SLOPE = 0.40

1Q SLOPE = -0.20

Appendix A: Flow Chart of Study Procedure



Total approximate time: 90 minutes

Appendix B: Thought Probes

The following 10 questions were presented at each thought probe. Participants were asked to respond using a 9-point Likert scale for each question. For Screen 1, the prompt was "Please answer the following questions based on how you feel *right now*," and the likert scale was anchored as 1 = Not at all, 9 = Extremely. For Screens 2-5, the prompt was, "Please answer the following questions for the time period *since the previous prompt*," and the likert scale was anchored as 1 = Not at all, 9 = Completely.

Screen 1:

How positive are you currently feeling?

How negative are you currently feeling?

Screen 2:

How much were you thinking about something other than the task?

How much were you thinking about your personal event?

Screen 3:

How much were you thinking about other people?

How much were you thinking about yourself?

Screen 4:

How much were you thinking about the past?

How much were you thinking about the future?

Screen 5:

How positive were your thoughts?

How negative were your thoughts?