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Published in:
Journal of psychopathology and clinical science

DOI:
[10.1037/abn0000752](https://doi.org/10.1037/abn0000752)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2022

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Hjartarson, K. H., Snorrason, I., Bringmann, L. F., & Ólafsson, R. P. (2022). Automaticity and depression: Daily mood-reactive rumination in people with and without depression history. *Journal of psychopathology and clinical science*, 131(4), 327–340. <https://doi.org/10.1037/abn0000752>

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Automaticity and Depression: Daily Mood-Reactive Rumination in People With and Without Depression History

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Depressive rumination has been conceptualized as a mental habit that is initiated automatically without conscious awareness, intent, or control in response to negative mood. However, it is unknown whether depression vulnerability is characterized by elevated levels of mood-reactive rumination at the level of short-term dynamics. Using mobile ecological momentary assessment, formerly depressed individuals with a recurrent history of depression ($n = 94$) and nonclinical controls ($n = 55$) recorded *in-the-moment* affect and rumination 10 times daily over 6 days, after completing baseline measures of trait ruminative brooding, early life stress, and habitual characteristics of negative thinking (e.g., automaticity, lack of conscious awareness, intent, and control). Momentary fluctuations in negative affect were prospectively associated with greater rumination at the next sampling occasion in formerly depressed participants whereas this pattern of mood-reactive rumination was not observed in nonclinical controls. In formerly depressed participants, habitual characteristics of negative thinking was associated with greater mood-reactivity of rumination, particularly among those with a history of early life stress. Mood-reactive rumination was not, however, associated with depression course nor with the frequency of trait ruminative brooding. Rumination may be triggered in response to negative affect with a high degree of automaticity, making it difficult to control. Greater mood-reactivity of rumination might be associated with increased depression risk, independent of the depressive course and may be exacerbated by early life stress. Future studies may need to go beyond frequency and focus on the role of mood-reactivity and automaticity of ruminative thinking in depression vulnerability.

General Scientific Summary

Ruminating when feeling sad is a risk factor for episode onset in major depressive disorder, yet rumination is frequently measured at a single point in time in the experimental setting not capturing the interaction between affect and cognition in daily life. The results of this experience sampling study revealed a dynamic temporal pairing between negative affect and subsequent state rumination in formerly (but not in never) depressed people, that were at increased risk of future depression episode. Mood-reactive rumination was characterized by increased automaticity of negative thoughts, moderated by early life stress, but not captured by traditional measures of trait rumination. Identifying daily ruminative habits and their distal causal factors will inform theory of cognitive vulnerability to depression recurrence and selection of prevention and treatment strategies.

Keywords: depression, rumination, habit, ecological momentary assessment, early life stress

Supplemental materials: <https://doi.org/10.1037/abn0000752.supp>

This article was published Online First April 7, 2022.

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The authors declare no conflicts of interest. The study was funded by research grants from the Icelandic Center for Research (Grant 173803-052, 173803-053) and the Eimskip Fund of The University of Iceland. The article was preposted on PsyArXiv.

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Efforts to identify indicators of depression risk have strongly implicated depressive rumination, a negative thinking style characterized by repetitive and passive thoughts about the causes, meanings, and consequences of one's feelings and distress (Nolen-Hoeksema et al., 2008). The response styles theory (Nolen-Hoeksema & Morrow, 1991), the principal theory of depressive rumination, defines rumination as an enduring and stable *habitual-like* cognitive response to sad mood. This suggests that mental habits may underpin a persistent disposition to ruminate following negative mood. Rumination has indeed been described as a mental habit in the depression literature (e.g., Hertel, 2004) and more recent theoretical frameworks of depression vulnerability continue to emphasize the role of habit in depressive rumination

(see, e.g., Shaw et al., 2019). Although the role of trait rumination has been extensively studied in the onset of both first and recurrent episodes, as well as episode maintenance in depression (Nolen-Hoeksema et al., 2008), it is still unclear if elevated mood-reactive rumination at the level of short-term dynamics characterizes those at increased risk for episode onset. Only few studies have addressed the temporal interplay between negative affect (NA) and rumination on shorter time scales, from moment to moment, as described by the response styles theory and more recent theoretical accounts of habitual rumination (e.g., Watkins & Nolen-Hoeksema, 2014). The current study aims to address this gap by utilizing ecological momentary assessment to better understand the dynamic interplay between NA and rumination in daily life in individuals at high risk of experiencing future depressive episodes.

Rumination as a Mood-Reactive Mental Habit

An increasingly popular theoretical perspective posits that depressive rumination is a mental habit that is initiated automatically without conscious awareness or intent in response to downward shifts in mood, making it persistent and difficult to control (Farb et al., 2015; Watkins & Nolen-Hoeksema, 2014; Shaw et al., 2019; Watkins & Roberts, 2020). Habits are behaviors that occur frequently and unintentionally (Orbell & Verplanken, 2010). They are formed by learned associations between behavioral responses and their performance contexts. Once formed, context cues become automatic triggers for the behavior, such that it is controlled solely by the presence of the context cues (Wood & Neal, 2007). Thus, habits are characterized by a degree of automaticity (e.g., lack of conscious awareness and deliberate intent, mental efficiency, and lack of control; Verplanken et al., 2007).

According to habitual accounts of rumination, transient episodes of ruminative thinking are thought to arise in response to perceived discrepancies between desired states and present reality. This process is considered adaptive when rumination facilitates progress toward desired states; however, when goals are repeatedly not reached, rumination persists, and mood deteriorates (Watkins, 2008). The consistent use of passive and abstract ruminative thoughts to cope with such persisting discrepancies cause NA and ruminative thinking to be paired over time, turning rumination into a habit triggered by context (i.e., NA) rather than intentions (Watkins & Nolen-Hoeksema, 2014). Person-specific factors that contribute to a lack of flexible responding and situational factors that systematically thwart important goals may serve as potential risk factors for transient episodes of rumination to consolidate into a habitual style of thinking (Shaw et al., 2019; Watkins & Roberts, 2020). Personally important goals may be chronically thwarted in abusive and stressful environments, generating repeated episodes of goal-discrepancy thoughts contingent on negative mood (Watkins & Nolen-Hoeksema, 2014). Stressful early life events, particularly a history of physical, sexual, and emotional abuse, predict elevated levels of rumination in adulthood (LeMoult et al., 2019) and rumination, in turn, has been found to mediate the relationship between childhood abuse and depression severity later in life (McLaughlin & Hatzenbuehler, 2009).

Empirical Support for Habitual Accounts

The brooding subscale of the Response Style Questionnaire (RRS; Nolen-Hoeksema & Morrow, 1991; Treynor et al., 2003) has often been considered a measure of habitual rumination, and numerous studies have found elevated levels of brooding in currently and remitted depressed individuals compared to nonclinical controls (reviewed in Aldao et al., 2010). However, the RRS only assesses the *frequency* of rumination in response to low mood (rated on a scale of repetition from *almost never* to *almost always*; Treynor et al., 2003) and does not assess other key characteristics of habits as automatically triggered behavioral responses (e.g., initiated without awareness, unintended, and difficult to control; Watkins & Roberts, 2020).

Some preliminary evidence exists for the rumination as-a-habit account. In a novel simulation study, Van Vugt and van der Velde (2018) showed that modeling rumination as-a-habit best predicted the impairments of depressed participants on a sustained attention task. Verplanken et al. (2007) also found that in a sample of university students rumination was strongly correlated with the Habit Index of Negative Thinking (HINT)—a self-report measure of the habitual characteristics of negative thoughts (i.e., repetition, lack of conscious awareness and deliberate intent, mental efficiency, lack of control and self-descriptiveness). Ólafsson et al. (2020) found that habitual characteristics of self-focused thoughts were elevated in formerly depressed individuals, compared individuals with no depression history. Ruminative brooding was found to be associated with increased habitual characteristics, whereas this relationship was not evident for ruminative reflection, often considered a more adaptive form of rumination (Ólafsson et al., 2020). Habitual characteristics of self-focused thoughts may also be associated stronger emotional response following experimental induction of brooding-like thinking style. Hjartarson et al. (2020) found, in a student sample, that higher scores on HINT were associated with slower return to baseline of negative emotions following induction of analytical and brooding-like thinking style frequently used in experimental studies (see Nolen-Hoeksema et al., 2008; Rimes & Watkins, 2005).

Although promising, these findings are limited in several ways. First, because rumination is measured at the trait level, at a single time-point and averaged across time, they may not apply to state fluctuations in affect and rumination. Second, rumination is measured with self-report, by asking respondents to think back to a time when they felt sad, increasing the probability of retrospective bias. Additionally, inducing rumination by asking participants to focus on a standardized battery of rumination-like questions may not generalize to habitual rumination automatically cued in daily life. Finally, previous studies did not address the hypothesized temporal context-response association between affect and rumination, rendering causal inference impossible.

One way to address these shortcomings is to use more ecologically valid assessment procedures, such as ecological momentary assessment (EMA), to capture the interplay between affect and rumination in the flow of daily life experiences. The longitudinal nature of EMA makes it ideally suited to examine temporal relationships between context and behavior on the microlevel (Myin-Germeys et al., 2018) and provides the basis for testing dynamic models empirically that has been missing so far. Studies using EMA in student samples have revealed a reciprocal relationship between affect and rumination at the level of short-term dynamics,

with rumination predicting subsequent changes in NA, and NA predicting changes in rumination to the same effect (Blanke et al., 2021; Hoorelbeke et al., 2016; Moberly & Watkins, 2008). Addressing the potential habitual nature of rumination more directly, Hjartarson et al. (2021) studied daily fluctuations in mood and rumination during a 6-day experience sampling period in a sample of 97 university students with a wide range of depressive symptoms. Participants also completed questionnaire measures of habitual characteristics (HINT) and ruminative brooding (RRS). Momentary increased NA predicted greater subsequent rumination at the next sampling occasion when associated with heightened levels of habitual characteristics—a finding that was only partially accounted for by trait levels of ruminative brooding. However, the moderating role of habitual characteristics was fully accounted for by current symptoms of depression, suggesting that, when habitual, mood-reactive rumination coincides with concurrent depression symptomatology.

Aims of the Current Study

The current study aimed to provide a test of the presumed mood-reactive nature of rumination. Habitual characteristics of negative thinking characterize euthymic formerly depressed, compared with healthy controls, and predict a stronger dynamic interplay between NA and daily rumination that overlaps with increased symptoms of depression in nonselective samples. This is in line with the theoretical framework of rumination as a persistent habit that confers risk for depression (Watkins & Roberts, 2020). We are not aware, however, of any EMA study that directly tests the assumption that individuals at increased risk of depression demonstrate elevated mood-reactive rumination in daily life. If habit-like triggering of daily mood-reactive rumination predisposes people to the onset of depression episodes, it should be observed in at-risk samples in a euthymic state and be unconfounded with current symptoms (e.g., Ingram et al., 2011). The current study was conducted in a sample of euthymic participants with a history of recurrent depression, and therefore at increased risk of future depression episode (e.g., Buckman et al., 2018). A low depression-risk group of euthymic non-clinical controls was recruited to serve as a comparison. We made two predictions derived from the theoretical framework of habitual rumination (Watkins & Nolen-Hoeksema, 2014; Shaw et al., 2019; Watkins & Roberts, 2020) and prior findings (Blanke et al., 2021; Hjartarson et al., 2021; Moberly & Watkins, 2008; Ólafsson et al., 2020).

Hypothesis 1: We expected formerly depressed individuals to demonstrate considerable mood-reactive rumination in daily life, such that momentary increased NA would prospectively predict greater rumination-levels at the next sampling occasion. However, we expected that mood-reactive rumination would not be apparent in more resilient healthy controls with no depression history.

Hypothesis 2: It is when depressive rumination turns habitual that it is thought to be triggered to a greater extent in response to negative mood. We therefore expected the degree of mood-reactive rumination in daily life of formerly depressed participants, to be moderated by habit, with heightened habitual characteristics of negative thinking predicting greater rumination in response to momentary fluctuations in NA.

To our knowledge, this is the first direct empirical test of the proposed mood-reactivity of rumination in the daily life of individuals with a history of depression. We followed these hypotheses with a number of exploratory analyses. As mentioned previously, early life stress might serve as a catalyst for habitual rumination through more systematic pairing between episodes of state ruminative thoughts and negative mood (Shaw et al., 2019; Watkins & Roberts, 2020). Furthermore, it is reasonable to expect rumination, that has consolidated as a persistent habit, to be associated with a more severe course of depression. We therefore explored if early life stress, particularly a history of physical, sexual, or emotional abuse, and depression course (number of episodes, age of onset, and stability of remission) was associated with greater mood-reactive rumination.

Method

Participants

Data were consecutively collected as a part of a randomized controlled trial (for preregistration see isrctn.com: No. 92714827). The current study is based on data collected at baseline prior to treatment. Ethics approval was attained from the National Bioethics Committee, the Bioethics Committee of the Primary Health Care, and reviewed by the Icelandic Data Protection Authority (protocol number VSN-235). Recurrent formerly depressed participants (RFDs) were recruited via referrals from general practitioners and mental health specialists in primary care centers, as well as through public advertisements, to participate in a trial on the efficacy of mindfulness based cognitive therapy (MBCT) for recurrent depression. Inclusion criteria included an age between 18 and 65 years and a history of three or more major depressive episodes but currently in remission. Exclusion criteria included a current major depressive episode and moderate or severe depression symptoms (a score >19 on the BDI-II; Beck et al., 1996). Nonclinical controls (NCs) were simultaneously recruited through public advertisements. Inclusion criteria included an age between 18 and 65 years and a score of 19 or lower on the BDI-II. Exclusion criteria included a presence or history of mental disorders. Detailed description of participant recruitment and inclusion criteria is provided in the Online Supplementary Material A.

Measures

Lifetime History of Depressive Episodes and Psychiatric Diagnoses

The MINI-International Neuropsychiatric Interview (MINI; Sheehan et al., 1998) was used to obtain psychiatric diagnoses. MINI is a semistructured interview for the most common Axis I disorder of the *DSM-IV*. The Icelandic version was administered for which adequate validity has been demonstrated (Kristjánsdóttir et al., 2015; Sigurðsson, 2008). The present study utilized a composite version of MINI with the depression module from MINI-Plus but with other modules from the standard MINI. Based on Ólafsson et al. (2020) questions were added to assess the number of past depressive episodes, age of onset, and the stability of remission. After confirming the presence of a past major depressive episode, participants were asked how often they had experienced such

an episode and to indicate when each episode had started and when it ended. Only episodes of adequate duration (2 weeks or more) that caused significant functional impairment and were separated by periods of remission (at least 2 months) were included. Participants also indicated if they had experienced one or both core symptoms (depressed mood/anhedonia) in the past 8 weeks, but with a shorter duration of at least 1 week. If endorsed, they were inquired about other potential symptoms using the same criteria. Stability of remission was defined as the total number of subclinical symptoms. We recorded audio from all MINI interviews. A sample of 22 recordings (approx. 20%) was randomly selected for reassessment by an independent researcher. Interrater reliability between the original evaluation and reassessment was 0.98, 95% CI [.96, .99] for number of previous episodes and .91, 95% CI [.78, .96] for age of onset. All participants sampled were found to have a history of at least three previous episodes but currently in remission with perfect agreement between raters.

Beck Depression Inventory (BDI-II)

The BDI-II is a 21-item self-report questionnaire that measures the severity of depression symptoms during the past 2 weeks (Beck et al., 1996). The Icelandic versions (Arnarson et al., 2008) has shown good psychometric properties. The BDI-II had an $\alpha = .87$ in the current study.

The Ruminative Responses Scale (RRS)

The RRS is a self-report measure of ruminative disposition which contains 22 items that assess a person's tendency to think about the symptoms, causes, and consequences of their depressed mood (Nolen-Hoeksema & Morrow, 1991). The current study utilized the five-item brooding subscale (RRS-B), which measures more passive, analytical and repetitive forms of thinking, and is thought to represent the maladaptive component of rumination (Treynor et al., 2003). The Icelandic version has shown good psychometric properties (Pálsdóttir & Pálsdóttir, 2008). In the current study RRS-B had an $\alpha = .81$.

Habit Index of Negative Thinking (HINT)

The habitual quality of negative thinking was measured with the HINT (Verplanken et al., 2007), a 12-item self-report scale that measures the degree to which self-focused negative thoughts occur frequently, are initiated without awareness, are unintended, are difficult to control, and are self-descriptive. Each item is rated on a 7-point scale in response to the general prompt; "Thinking negatively about myself is something . . ." and included items such as "I do unintentionally" and "I start doing before I realize I'm doing it." The Icelandic version has shown high internal consistency and good discriminant validity (Ólafsson et al., 2019). In the current study HINT had an $\alpha = .96$.

Early Life Stress

The Childhood Traumatic Events Scale (CTES; Pennebaker & Susman, 1988) was used to assess participants' history of early life stress before the age of 17. Participants were asked whether they had experienced certain stressful events, the age at which they experienced them (not reported here), how traumatic the event had been on a 7-point scale (1 = *not at all traumatic*, 7 = *extremely traumatic*). Events included: physical abuse; mugging

or assault; sexual abuse or molestation; major parental conflicts; death of a family member or person very close to the child; severe illness or injury; and other traumatic events which were perceived to impact the individual's personality or life trajectory. An additional item to assess history of emotional abuse was added in the present study; "Prior to the age of 17, did a parent or other household member frequently swear at you, degrade or humiliate you?" based on questions in other well-established measures of adverse childhood experiences (e.g., the ACE scale; Felitti et al., 1998). The CTES yielded a cumulative score, by summing the number of stressful early life events, and a total severity score, calculated by summing the severity of each reported event. The CTES demonstrates good reliability and validity (Pennebaker & Susman, 1988) and sensitivity to clinical symptoms following early life stress, including posttraumatic stress disorder (PTSD) and depression (Scheller-Gilkey et al., 2004).

Momentary Mood Ratings

Participants rated their current mood at each alert during the EMA period. The choice of items was based on the widely used Positive and Negative Affect Schedule (PANAS; Watson et al., 1988) and previous EMA studies (revealing items with high loadings on NA; e.g., Wichers et al., 2012). NA consisted of the following items: (a) I feel sad right now, (b) I feel irritable right now, and (c) I feel guilty right now. Participants responded using a five-point scale from 1 (*not at all*) to 5 (*very much*). NA had an $\alpha = .97$ at the between-level and $\alpha = .54$ at the within-level and was strongly correlated with BDI-II ($r = .53$).¹

Momentary Rumination

An abbreviated form of the Momentary Ruminative Self-Focus Inventory (MRSI-A; Connolly & Alloy, 2017; Hjartarson et al., 2021) was chosen for use during the EMA period which contained three items: (a) Right now, I am thinking about how happy or sad I feel, (b) Right now, I wonder why I react the way I do, and (c) Right now, I am thinking about the possible meaning of the way I feel. Participants indicated their degree of rumination at the time of the alert using a 7-point scale, from 1 (*strongly disagree*) to 7 (*strongly agree*). The MRSI-A has shown excellent internal consistency and is correlated with alternative measures of rumination (Connolly & Alloy, 2017) and has been found to be sensitive to changes in response to experimental manipulations of depressive rumination (e.g., Grol et al., 2015; Hertel et al., 2014). The MRSI-A had an $\alpha = .98$ at the between-level and $\alpha = .83$ at the within-level and was moderately correlated with RRS-B ($r = .33$; see Footnote 1).

Procedure

Baseline Assessment

Participants partook in a 2-hr in-laboratory session. Participants completed self-report questionnaires and were briefed one-on-one on the EMA procedure by a research assistant following a standardized research protocol. The EMA items were explained by a research assistant, exemplifying the meaning of each item and

¹ Correlations are based on within-person averages of NA and MRSI-A.

answering any questions. Participants then reviewed a sample EMA alert with the researcher to ensure proper understanding of the smartphone app and the sampling procedure.

EMA Assessment

Beginning the following day after the in-lab assessment, participants were prompted by the smartphone app to answer 10 alerts per day for 6 consecutive days during a 12-hr period (between 10 a.m. and 10 p.m.). Alerts were programmed according to a stratified semirandom interval scheme. Each day was divided into 10 72-min intervals, with a signal occurring randomly within each interval, with an average of 92-min between alerts. Each time, participants gave their momentary rating of NA and rumination. Participants were instructed to answer given how they felt and thought “in-the-moment” just before the alert and to complete the measures immediately upon receiving an alert. After receiving an alert, participants had 25 min to respond before it expired. Alerts were presented and responses collected using The Experience Sampler App (Thai & Page-Gould, 2018) an open-source app for EMA research (www.experiencesampler.com).

Debriefing

Upon completing the EMA period, participants returned to the laboratory where they were debriefed and received compensation for their participation (approx. €30).

Statistical Analyses

Analyses were conducted in Mplus Version 8.5 (Muthén & Muthén, 2017) and in R Version 4.3 (R Core Team, 2020) using the packages *ggplot2* for data visualization (Wickham, 2009) and *psych* for estimating multilevel reliability (time nested within people) and to calculate mean squared successive difference scores (MSSDs), which provide the average magnitude of each person’s moment-to-moment fluctuations in NA and rumination (Revelle, 2020). Participants with fewer than 12 out of 60 (20%) completed alerts were excluded from the analyses. Previous research has shown that EMA assessment with less than 30% completed alerts may be unreliable (Delespaul, 1995). The same pattern of findings was observed when using a more conservative criteria of at least 20 out of 60 valid alerts. We therefore present results based on a more inclusive sample in our analyses. Given the nested structure of the data (repeated assessments within individuals) we utilized dynamic structural equation modeling (DSEM) in Mplus, a multilevel approach to analyzing EMA data (Hamaker et al., 2018). Using DSEM we fitted cross-lagged models to investigate the dynamic relationship between momentary affect and rumination. The models were run using Bayesian estimation with noninformative priors. We used 50,000 iterations on two independent Monte Carlo Markov Chains, of which every 10th was recorded for estimation purposes. A Bayesian approach is used in DSEM because it allows for the simultaneous estimation of multiple outcome variables and their covariances and the accurate modeling of time-series data with unequal intervals between measurement occasions (Schuurman et al., 2016). We provide standardized results for within-person and between-person effects. All continuous between-level variables were grand-mean centered. Statistical significance is based on the credible

interval not containing zero (the default in DSEM). The corresponding Mplus code is included in the [Online Supplementary Material B](#).

Hypothesis 1: Group Differences in Mood-Reactive Rumination in the Daily Life of RFDs and NCs

To test our hypothesis that momentary fluctuations in NA predict subsequent rumination in RFDs but not NCs, three successive models were computed. A visual representation of the models is shown in [Figure 1](#).

We first modeled the within-person relationships between momentary NA and rumination for each group separately to estimate significant paths within each group ([Figure 1a](#)). NA and rumination at any given time-point (t) were predicted by NA and rumination at the previous time-point ($t - 1$). We were interested in the effect of the variables on themselves (autoregressive paths) and on each other (cross-lagged paths). These associations were allowed to differ between individuals (i.e., random means and slopes). We follow Hamaker et al. (2018) in presenting our models. The models decompose affect and rumination into latent within- and between-person components. The within-person components describe affect and rumination of individual i at time t :

$$\begin{aligned} Affect_{it} &= \mu_{NA,i} + \varphi_{1i} NA_{it-1}^{(w)} + \varphi_{3i} Rumination_{it-1}^{(w)} + \zeta_{1it} \\ Rumination_{it} &= \mu_{Rumination,i} + \varphi_{2i} Rumination_{it-1}^{(w)} + \varphi_{4i} NA_{it-1}^{(w)} \\ &\quad + \zeta_{2it} \end{aligned} \quad (1)$$

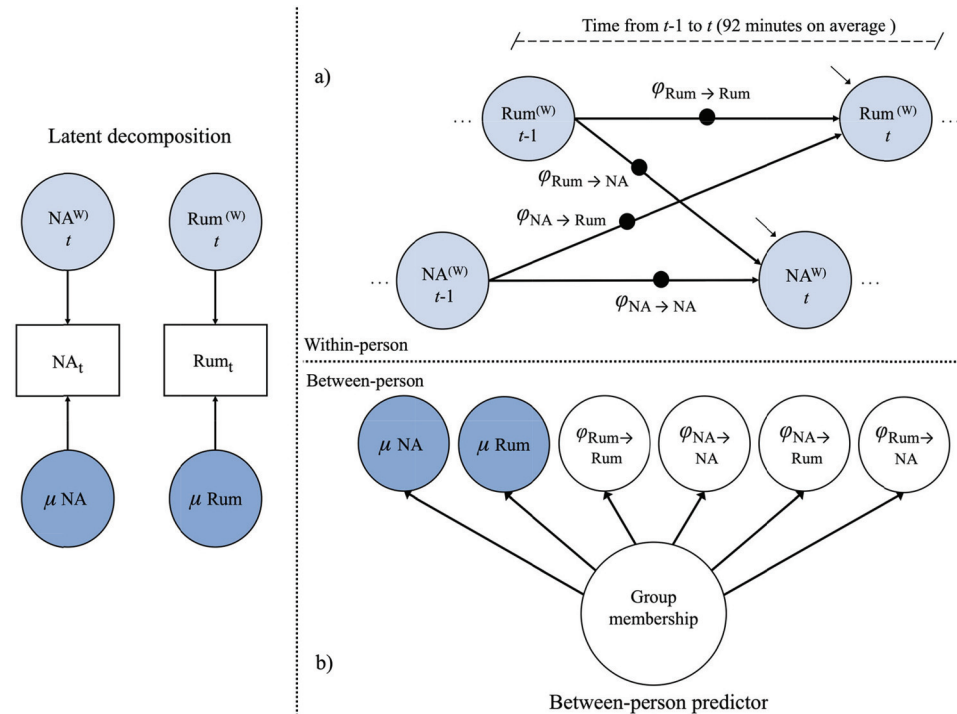
where $\mu_{Affect,i}$ and $\mu_{Rumination,i}$ are the time-invariant (between-person) means of affect and rumination for individual i . The autoregressive parameters φ_{1i} and φ_{2i} represent the effect of the variables at $t - 1$ on themselves at time t . The cross-lagged parameters φ_{3i} and φ_{4i} are the effects of the variables at $t - 1$ on each other at time t . The parameters ζ_{1it} and ζ_{2it} represent the residual variation at time-point t not explained by rumination and affect at the previous time-point $t - 1$. Both the means μ_i and the lagged parameters φ_i are allowed to vary across individuals (hence the subscript i). Scores were latent person-mean centered to better capture fluctuations in NA and rumination relative to individuals’ mean levels during the assessment period (the default in DSEM; Asparouhov et al., 2018).

Using the whole sample, we then estimated the effect of group membership on the between-level (see [Figure 1b](#)) on the autoregressive and cross-lagged parameters on the within-person level (dichotomous; 1 = RFDs, 0 = NCs):

$$\begin{aligned} \mu_{NA,i} &= \gamma_{00} + \gamma_{01} Group_i + u_{0i} \\ \mu_{Rumination,i} &= \gamma_{10} + \gamma_{11} Group_i + u_{1i} \\ \varphi_{1i} &= \gamma_{20} + \gamma_{21} Group_i + u_{2i} \\ \varphi_{2i} &= \gamma_{30} + \gamma_{31} Group_i + u_{3i} \\ \varphi_{3i} &= \gamma_{40} + \gamma_{41} Group_i + u_{4i} \\ \varphi_{4i} &= \gamma_{50} + \gamma_{51} Group_i + u_{5i} \end{aligned} \quad (2)$$

where γ_{00-50} is the fixed average of the parameters and u_i is the individual deviations from these effects. On the between-level, group membership, denoted as γ_{Group} , was included as a predictor of the person-specific means and person-specific autoregressive

Figure 1
Multilevel Cross-Lagged Model Estimating the Effect of Group Membership on the Temporal Associations Between Momentary Negative Affect (NA) and Rumination (RUM)



Note. Black dots indicate random effects. ^(w) represent within-person estimates. See the online article for the color version of this figure.

and cross-lagged associations. All parameters were allowed to covary.

Hypothesis 2: Habitual Characteristics Predict Mood-Reactive Rumination in Daily Life of RFDs

To test whether habitual characteristics (HINT) was a predictor of mood-reactive rumination in RFDs, we computed the cross-lagged model (see Figure 1) using HINT instead of group membership as our between-level predictor (Equation 2) of the autoregressive and cross-lagged associations between NA and rumination on the within-person level (Equation 1). If fluctuations in NA trigger subsequent ruminative thinking as a function of habit, stronger $\phi_{NA \rightarrow Rum}$ associations should be associated with greater habitual characteristics (HINT).

Exploratory Analyses: The Role of Depression Course and Early Life Stress in Mood-Reactive Rumination in Daily Life of RFDs

We also explored if mood-reactive rumination in RFDs was associated with the depression course (age of onset, number of episodes, stability of remission) and history of early life stress (cumulative early life stress, perceived stress severity, and history of abuse [physical, sexual, or emotional]). We first computed the cross-lagged model (see Figure 1) in RFDs and entered each exploratory variable individually on the between-level (Equation 2), as predictors of the autoregressive and cross-lagged associations

on the within-person level (Equation 1). We then explored whether the effect of each variable was moderated by habitual characteristics (HINT) by simultaneously entering each individual variable (γVAR) along with HINT on the between-level as well as adding an interaction term $HINT * \gamma VAR$, created by multiplying each variable by scores on HINT (no correction for multiple testing). Due to the low number of RFDs reporting four or more stressful early life events, they were collapsed into one category, resulting in cumulative stress scores between 0 and 4. When analyzing the models for subgroups events were dummy coded (1 = history of abuse, 0 = no history of abuse).

Results

Sample Characteristics

A total of 103 RFDs were included in the trial, of which 94 (19 men, 75 women) provided sufficient EMA data ($\geq 20\%$) to be included in the analyses. In total 55 NCs (12 men, 43 women) were recruited, all of which provided adequate EMA responding. See Table 1 for details on the characteristics of both samples. RFDs had experienced an average of 7.1 ($SD = 3.6$) lifetime depressive episodes and mean age of first-episode onset was 18.1 ($SD = 6.9$) years. There were no significant differences between the groups concerning age (mean age of 36.8 vs. 39.7), gender, relationship status, educational level, or current employment

Table 1
Demographic and Clinical Characteristics of Formerly Depressed and Healthy Nonclinical Controls

Characteristic	Formerly depressed (<i>n</i> = 94)		Nonclinical controls (<i>n</i> = 55)		Statistic	χ^2
	<i>M</i> (<i>SD</i>)	%	<i>M</i> (<i>SD</i>)	%		
Age (years)	36.8 (10.9)		39.7 (11.9)		<i>t</i> (147) = -1.492, <i>p</i> = .138	
Gender (males)	19	20.2	12	22		$\chi^2(1, N = 149) = 0.001, p = .981$
Relationship status						$\chi^2(4, N = 149) = 3.634, p = .458$
Married	34	36.2	23	42		
Single	30	32	10	18		
Relationship	8	9	5	9		
Cohabitation	20	21	16	29		
Other	2	2	1	2		
Education (final level)						$\chi^2(3, N = 149) = 0.848, p = .838$
High school	7	7	6	11		
Gymnasium	34	36	17	31		
College, undergraduate level	33	35	19	35		
College, graduate level	20	21	13	24		
Employment status						$\chi^2(1, N = 149) = 0.181, p = .671$
Employed	71	76	44	80		
Unemployed	23	24	11	20		
Employment percentage	79.6 (29)		87.2 (24.2)		<i>t</i> (105.09) = -1.692, <i>p</i> = .094	$\chi^2(1, N = 149) = 0.307, p = .580$
Student	36	38	18	33		
Age at depression onset (<i>M, SD</i>)	18.1 (6.88)					
Number of MDD episodes (<i>M, SD</i>)	7.14 (3.64)					
Stability of remission (<i>M, SD</i>)	0.957 (1.91)					
Comorbid diagnosis						
Yes (at least one)	25					
No	69					
Total of comorbid diagnoses	24					
Anxiety disorders	27					
Eating disorders	1					
CTES						
Number of stressful events	2.43 (1.75)		1.55 (1.136)		<i>t</i> (147) = -3.205, <i>p</i> = .002	
Severity	12.2 (10.1)		6.61 (7.23)		<i>t</i> (140.9) = -3.951, <i>p</i> < .001	
History of physical, sexual, or emotional abuse	47	50	14	25.5		$\chi^2(1, N = 149) = 7.661, p = .006$
HINT						
RRS-brood	11.6 (3.01)		32.2 (16.2)		<i>t</i> (147) = -12.389, <i>p</i> < .001	
BDI	8.57 (5.97)		6.85 (1.59)		<i>t</i> (145.81) = -12.463, <i>p</i> < .001	
			2.18 (2.82)		<i>t</i> (141.92) = -8.827, <i>p</i> < .001	

Note. CTES = Childhood Traumatic Events Scale; HINT = Habit-Index of Negative Thinking; RRS-brood = Ruminative Response Scale-brooding; BDI-II = Beck Depression Inventory.

status. As might be expected, RFDs worked somewhat lower percentages compared with NCs. On average, RFDs reported a greater number of stressful early life events and were more likely to have a history of abuse. RFDs also showed higher levels of depression (BDI-II), habitual-characteristics (HINT) and trait levels of brooding (RRS-brood). Noncompleters (those who did not provide a sufficient number of responses) did not significantly differ from the sample with regards to age, gender ratio, relationship status, educational level, or employment status (see [Online Supplementary Material G](#)).

Preliminary Analyses of EMA Data

Participants completed a total of 6,008 EMA alerts (RFDs = 3,733; NCs = 2,275). RFDs completed on average 66% (range = 20%–93%) of the EMA alerts compared with 69% (range = 20%–95%) in the NCs, with no-significant difference between the groups, $t(107.5) = .86$, $p = .394$. Across time, ratings of momentary NA were significantly higher in RFDs ($M = 4.27$, $SD = .98$) than in NCs ($M = 3.28$, $SD = .32$), $t(123.3) = 9.02$, $p < .001$. In addition, RFDs demonstrated more moment-to-moment fluctuations in NA (MSSD = 2.67, $SD = 2.76$) compared with NCs (MSSD = .87, $SD = 1.14$), $t(135) = 5.58$, $p < .001$. The groups did not differ in their average level of momentary rumination ($M = 6.87$, $SD = 3.14$, in RFDs vs. $M = 6.10$, $SD = 3.57$, in NCs), $t(101.7) = 1.34$, $p = .185$. However, RFDs showed more pronounced moment-to-moment fluctuations in rumination (MSSD = 16.61, $SD = 12.21$) compared with NCs (MSSD = 6.81, $SD = 8.12$), $t(144.5) = 5.87$, $p < .001$. M levels of NA and rumination did not change as a function of time during the EMA assessment period.² Between-person correlations of trait and EMA measures are provided in [Online Supplementary Material H](#).

Hypothesis 1: Group Differences in Mood-Reactive Rumination in the Daily Life of RFDs and NDs

The effect of group on the temporal associations between NA and rumination is presented in [Figure 2](#) and their corresponding paths are visualized in [Figure 1](#). Detailed model results are provided in [Online Supplementary Material C](#) and [D](#). Group was a significant predictor of mood-reactive rumination (group on $\phi_{NA \rightarrow Rum}$) during the EMA assessment period ($B = .247$, $SD = .10$, 95% CI [.04, .45]). The cross-lagged association between NA and subsequent rumination was significant in RFDs ($\phi_{NA \rightarrow Rum}$; $B = .086$, $SD = .02$, 95% CI [.04, .13]) but not in NCs ($B = -.005$, $SD = .05$, 95% CI [-.09, .09]), when controlling for both initial levels of rumination and the effect that rumination had on subsequent mood.³ Mood-reactive rumination did not change as a function of time in either group during the EMA period.⁴ Given the significant difference between groups in current depressive symptoms (see [Table 1](#)), we entered BDI-II and group membership simultaneously on the between-level, to control for possible confounds with current depressive status. Group membership still remained a significant predictor of greater mood-reactive rumination (group on $\phi_{NA \rightarrow Rum}$; $B = .260$, $SD = .12$, 95% CI [.17, .51]). Group also emerged as a significant predictor of the cross-lagged association between rumination and subsequent NA (see [Figure 2](#); group on $\phi_{Rum \rightarrow NA}$; $B = .148$, $SD = .06$, 95% CI [.03, .27]), with increased rumination leading to greater subsequent levels of NA ($\phi_{Rum \rightarrow NA}$) in RFDs ($B = .038$; $SD = .01$, 95% CI [.02, .06]) but not in NCs ($B = -.022$; $SD = .03$, 95% CI [-.08, .05]).

Hypothesis 2: Habitual Characteristics Predict Mood-Reactive Rumination in Daily Life of RFDs

To test whether mood-reactive rumination is associated with habitual characteristics of negative thinking (HINT), a cross-lagged model using HINT as a between-level predictor was tested in RFDs where NA was shown to be a significant predictor of rumination across time. HINT was significantly associated with larger cross-lagged parameters between NA and subsequent rumination in RFDs (HINT on $\phi_{NA \rightarrow Rum}$; $B = .253$, $SD = .12$, 95% CI [.02, .49]). Detailed full model results for HINT are provided in [Online Supplementary Material E](#). This relationship is depicted in [Figure 3](#) which shows that when associated with greater trait habitual characteristics, a momentary increase in NA evoked heightened rumination on the next measurement occasion.

Additional analyses were carried out to test the robustness of this findings. When controlling for RRS-brooding, entered simultaneously with HINT on the between-level, HINT still remained a significant predictor of cross-lagged path between NA and subsequent rumination (HINT on $\phi_{NA \rightarrow Rum}$; $B = .282$, $SD = .12$, 95% CI [.04, .51]) whereas RRS-brooding did not demonstrate a significant effect (RRS-brooding on $\phi_{NA \rightarrow Rum}$; $B = -.15$, $SD = .12$, 95% CI [-.39, .09]). RRS-brooding, when entered as the only predictor in the model, was a significant predictor of average momentary levels of rumination (RRS-brooding on μ_{Rum} ; $B = .184$, $SD = .07$, 95% CI [.04, .32]), however, it did not significantly predict the cross-lagged path between NA and subsequent rumination (RRS-brooding on $\phi_{NA \rightarrow Rum}$; $B = -.09$, $SD = .12$, 95% CI [-.34, .15]). Furthermore, when entering depressive symptoms simultaneously with HINT on the between-level, HINT still emerged as a significant predictor of greater mood-reactive rumination (HINT on $\phi_{NA \rightarrow Rum}$; $B = .260$, $SD = .12$, 95% CI [.17, .50]) while depressive symptoms did not (BDI-II on $\phi_{NA \rightarrow Rum}$; $B = -.01$, $SD = .12$, 95% CI [-.23, .24]).

Exploratory Analyses: The Role of Depression Course and Early Life Stress in Mood-Reactive Rumination in Daily Life of RFDs

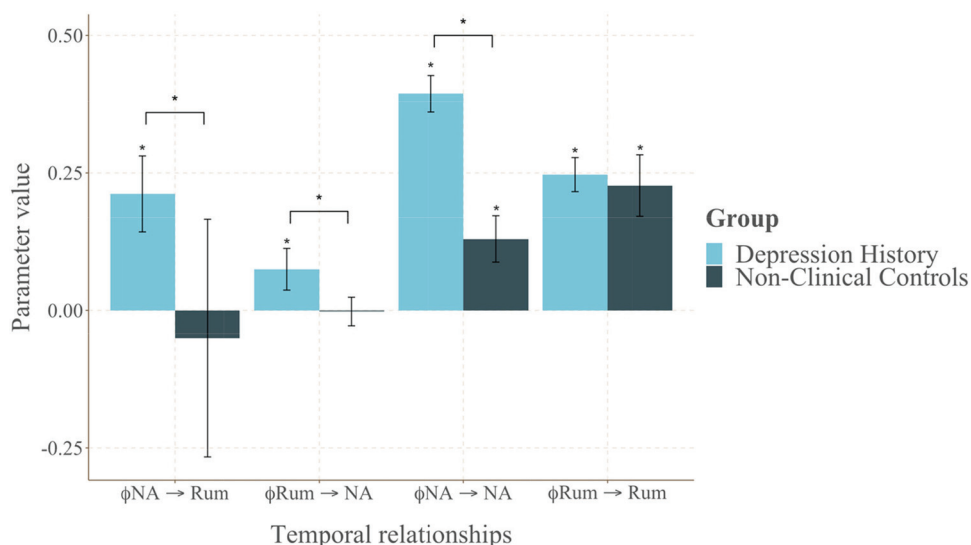
We also explored if mood-reactive rumination in daily life of RFDs was associated with early life stress and depression course. Results of the main analyses are presented in [Figure 4](#). Detailed results are provided in [Online Supplementary Material F](#). As can be seen in [Figure 4](#), depression course (number of depressive episodes, age of onset,

² There were no significant trends for either group in momentary levels of NA or rumination. No effects were found for the time of day (start and end of day), day of EMA, or time of measurement. The current results remained unchanged when time of measurement was inserted in the within-part of the models to control for trends or non-stationary of the data during the EMA assessment period.

³ It should also be noted that the contemporaneous association between NA and rumination was stronger in RFDs ($B = 0.197$, $SD = 0.02$, 95% CI [0.16, 0.23]) than in NCs ($B = 0.171$, $SD = 0.02$, 95% CI [0.13, 0.21]) although both groups demonstrated a significant relationship.

⁴ Additional models found no effect for time of day, day of EMA, or time or measurement on mood-reactive rumination (all credible intervals contained zero). These were run using a cross-classified extension of the two-level model that separates the between-level into person-specific and time-specific effects, which is needed for the analysis of trends in between-level latent variables (see [Asparouhov et al., 2018](#)).

Figure 2
Temporal Relationships Between Negative Affect (NA) and Momentary Rumination (MRSI-A) in Daily Life (EMA Assessment) in Recurrent Formerly Depressed Individuals Compared to Nonclinical Controls



Note. Point estimates (posterior means) of cross-lagged ($\phi_{NA \rightarrow Rum}/\phi_{Rum \rightarrow NA}$) and autoregressive ($\phi_{NA \rightarrow NA}/\phi_{Rum \rightarrow Rum}$) paths are shown. Error bars indicate the standard deviation of the posterior distributions. *Statistical significance is based on the 95% credible interval not containing zero. See the online article for the color version of this figure.

stability of remission) did not emerge as significant predictors of mood-reactive rumination nor did habitual characteristics (HINT) moderate their effect to any significant degree.

Self-reported severity of early life stress did not emerge as a significant predictor of mood-reactive rumination. Cumulative early life stress before the age of 17 (see Table 1) was, however, a significant predictor of larger cross-lagged associations between NA and subsequent rumination in RFDs (Cumulative stress on $\phi_{NA \rightarrow Rum}$; $B = .270$; see Figure 4). Additional analyses were carried out to assess if this finding was specific to the type of early life stress in question. RFDs with a history of abuse (dummy coded as 1 or 0), demonstrated significantly greater mood-linked rumination compared with RFDs that did not report an early life experience of abuse (Abuse on $\phi_{NA \rightarrow Rum}$; $B = .261$). Although cumulative early life stress did not interact with self-reported habitual characteristics (HINT) in predicting mood-reactivity of daily ruminative thoughts (HINT \times Cumulative stress on $\phi_{NA \rightarrow Rum}$; $B = .01$, $SD = .13$, 95% CI [-1.5, .35]), a history of abuse did (HINT \times Abuse on $\phi_{NA \rightarrow Rum}$; $B = .332$, $SD = .15$, 95% CI [.02, .60]). This relationship is depicted in Figure 5. Habitual characteristics of self-focused negative thinking (HINT) significantly predicted stronger temporal pairing between NA and subsequent rumination in participants reporting physical, sexual, or emotional abuse before age of 17, but not in RFDs reporting no such history of abuse.

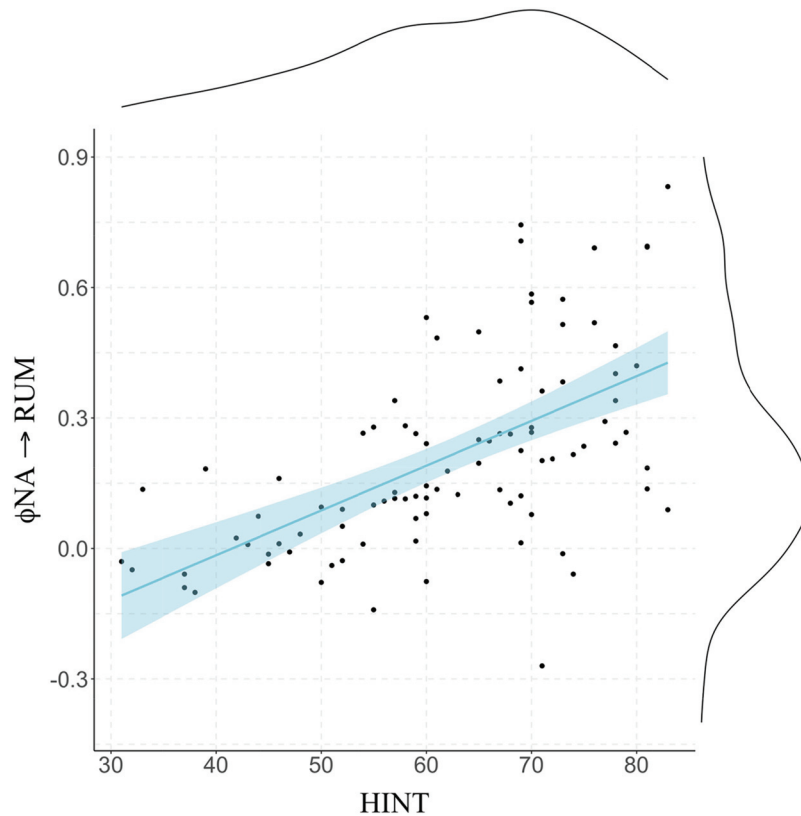
Discussion

Measures of the dynamic interplay between NA and rumination in daily life revealed significant mood-related reactivity of state ruminate thoughts in recurrent formerly depressed participants, but

not healthy controls. To our knowledge, this is the first explicit test of the mood-reactivity of depressive rumination using mobile EMA assessment in a clinical sample. These findings extend previous results (Blanke et al., 2021; Hjartarson et al., 2021; Hoorelbeke et al., 2016; Moberly & Watkins, 2008) by showing that fluctuations in everyday NA may act as a trigger of subsequent ruminative thinking in euthymic individuals at high risk of experiencing depressive episodes. This is in line with recent theoretical accounts that define depressive rumination as a stable and enduring cognitive process that has become conditioned on negative mood (Watkins & Nolen-Hoeksema, 2014; Shaw et al., 2019). Importantly, these findings held when controlling for current depressive symptoms, in line with theoretical accounts of mood-reactive ruminative thinking as a potential vulnerability or risk marker (Watkins & Nolen-Hoeksema, 2014) and not just a concomitant of current depressive states (e.g., Ingram et al., 2011).

Like previous studies we identified a reciprocal relationship between NA and rumination, with rumination predicting subsequent changes in NA, and NA predicting changes in rumination to the same effect. However, the current findings suggest that mood-reactive rumination might be limited to individuals at-risk for depression. This does not necessarily contradict previous findings. Indeed, the few existent studies (Blanke et al., 2021; Hjartarson et al., 2021; Moberly & Watkins, 2008) were limited to student samples including individuals with a wide range of depressive symptoms and recruited both those who were and were not prone to depression. Furthermore, the mood-reactivity of rumination was found to be moderated (Moberly & Watkins, 2008) and fully accounted for by current depressive symptomatology (Hjartarson et al., 2021). In line with this, the healthy control group utilized in

Figure 3
Negative Affect (NA) Predicting Subsequent Rumination (MRSI-A) in Daily Life (EMA Assessment) in Formerly Depressed Individuals as a Function of Habitual Characteristics (HINT)



Note. Raw estimates of cross-lagged parameters $\phi_{NA \rightarrow RUM}$ are shown. Each dot corresponds to one participant with a history of depression. Marginal plots show density distributions for HINT and the cross-lagged parameters. See the online article for the color version of this figure.

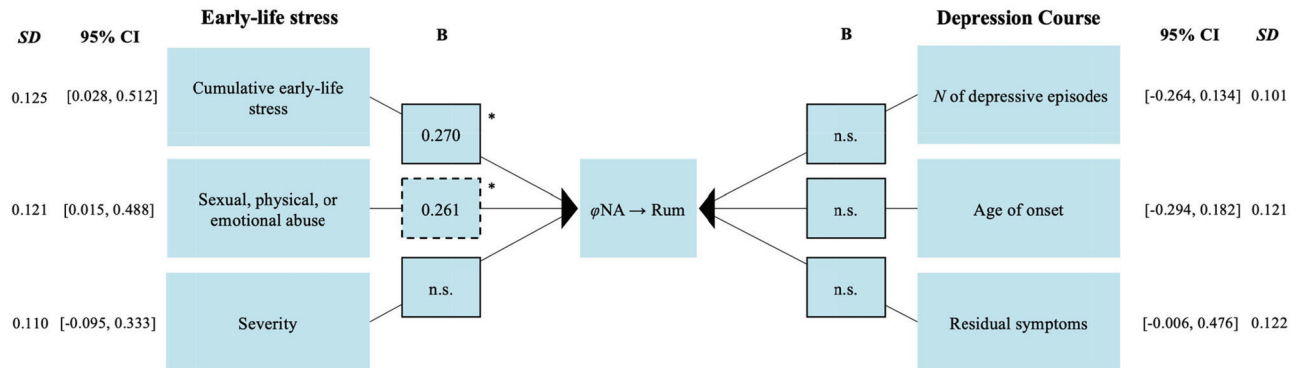
the current study, which did not have any diagnosable history of depression or other mental disorders, did not demonstrate such mood-reactivity of rumination in daily life. Together these findings suggest that mood-reactive rumination varies according to the depression-risk spectrum in line with theoretical accounts of depressive rumination (Shaw et al., 2019; Watkins & Nolen-Hoeksema, 2014; Watkins & Roberts, 2020) and highlights the need to take differing levels of depression risk into account in future studies on mood-reactive rumination.

We also found that increased microlevel shifts in mood-dependent ruminative thinking were associated with the perceptions of one's negative self-focused thoughts being automatically triggered without intention and control. This replicates previous findings of Hjartarson et al. (2021) and is consistent with recent conceptualizations of depressive rumination as a response triggered by context (i.e., downward shifts in mood) rather than goals or intentions (Farb et al., 2015; Watkins & Nolen-Hoeksema, 2014; Shaw et al., 2019; Watkins & Roberts, 2020). Because mood-reactive rumination was only evident in at-risk individuals, and habitual characteristics specifically predicted the strength of the reactivity, this suggests that depression risk may be in the form of rumination

being triggered with a high degree of automaticity in response to daily fluctuations in negative affect, making it difficult to control.

The emphasis that habitual accounts place on the automaticity of ruminative thinking is novel given that traditional instruments that assess rumination only measure the frequency of ruminative thinking in response to negative mood (Treyner et al., 2003; Watkins & Roberts, 2020). HINT (but not brooding) was a significant predictor of the temporal pairing of NA and subsequent rumination whereas it did not predict the dynamic pairing between rumination and subsequent NA. Thus, the impact of rumination on affect was not associated with habitual characteristics, further highlighting the specificity of the current findings. Importantly, HINT remained a unique predictor of mood-reactive rumination when controlling for trait levels of brooding and current depressive symptoms. This suggests that HINT assesses aspects of mood-reactive rumination not fully captured by traditional trait measures of rumination and which cannot be explained by confounds with current depression status or overlap in negative content of the self-report measures. Thus, we may need to go beyond frequency to tap depression risk and concentrate on reactivity and automaticity, in addition to trait or mean levels of rumination.

Figure 4
Early Life Stress (CTES) and Depression Course (MINI Depression Module) Predicting Mood-Linked Rumination ($\phi_{NA \rightarrow Rum}$) in Daily Life (EMA Assessment) in Formerly Depressed Individuals (Standardized Effects)

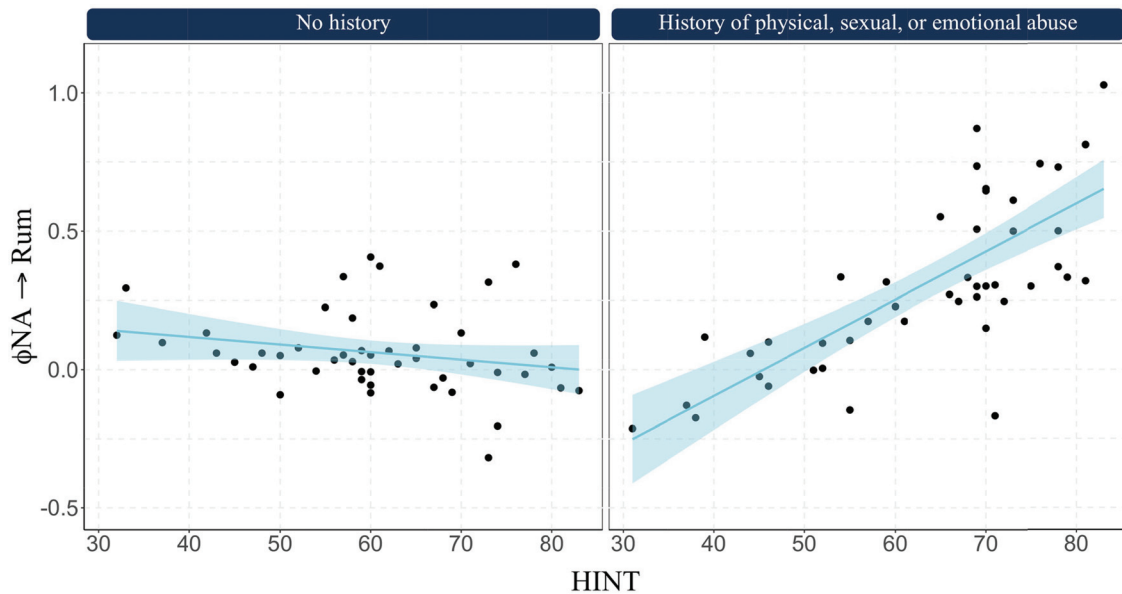


Note. Dashed lines signify effects moderated by habitual characteristics (HINT). n.s. = not significant. * Statistical significance is based on the 95% credible interval not containing zero. See the online article for the color version of this figure.

Depression course (number of episodes, age of onset, and stability of remission) was not associated with mood-reactive rumination in daily life. This could reflect the homogeneity of the current clinical sample, consisting of high-risk individuals with at least three lifetime depressive episodes, excluding the lower end of vulnerability and potentially inhibiting the ability to detect these effects (cf. Buckman et al., 2018), but may also indicate a mechanism independent of the depression course that constitutes a risk or vulnerability on its own (Shaw et al., 2019). Consistent with this view, we found that RFDs with a history of physical, sexual, or emotional abuse before the age of 17 demonstrated greater

levels of mood-reactive rumination. Furthermore, habitual characteristics (HINT) predicted stronger mood-reactive rumination in RFDs reporting physical, sexual, or emotional abuse but not in RFDs without such a history. Prior findings show that rumination is associated with a history of early life stress and abuse (LeMoult et al., 2019) and recent habitual accounts of rumination suggest that stressful and abusive environments may constrain peoples' emotional coping repertoire, consolidating rumination as a mental habit when paired with negative mood over time (Shaw et al., 2019; Watkins & Roberts, 2020). Evidence suggests that stressful early life events play a role in internalizing psychopathology

Figure 5
Habitual Characteristics (HINT) Moderating the Effect of Early Life Stress (Physical, Sexual, or Emotional Abuse) on Mood-Linked Rumination in the Daily Life (EMA Assessment) of Formerly Depressed Individuals



Note. Raw estimates of cross-lagged parameters $\phi_{NA \rightarrow Rum}$ are shown. Each dot corresponds to one participant with a history of depression. See the online article for the color version of this figure.

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through sensitization processes (McLaughlin et al., 2019) and reduced cognitive control (Jenness et al., 2020) that may pave the way for habit formation (e.g., Gordon et al., 2020).

Our results should also be interpreted in light of some limitations. Although the intensive longitudinal EMA methodology of the current study provided an inference of temporal causality, effects were generally small to moderate in size. Other contributing factors might also cause NA to evoke a subsequent ruminative response. Furthermore, although the current investigation identified the automaticity of mood-reactive rumination at the level of short-term dynamics as a potential risk factor, it remains to be tested whether it predicts depression onset and relapse using prospective designs and under what conditions it results in such emotional cascades (e.g., at times of heightened and persistent NA). Also, formerly depressed participants were required to have at least three previous episodes, in line with criteria used in studies of MBCT in recurrent depression (e.g., Williams et al., 2014). Although supporting our aim to study mood-reactive rumination in a group at high-risk of depression, this requirement precludes conclusions being drawn regarding people with fewer episodes. Although formerly depressed participants were in a euthymic state, as defined by not meeting diagnostic criteria for major depressive episode and having scores below established cut-off on measure of depressive symptoms, they had elevated mean levels of daily negative affect during the EMA. However, controlling for depressive symptoms did not change the pattern in the findings, providing reassurance that our results are not confounded with current depressive states during the assessment period.

There exist yet no reliable behavioral proxies to measure rumination as-a-habit. In the current study, habitual characteristics were inferred from self-report. This highlights the need for the development of more specific behavioral measures of habitual rumination to clarify the unique role of habit in depressive rumination, while the research base of existing measures is expanded and their link with related constructs explored (e.g., metacognitive beliefs). Similarly, even though mood-reactive rumination was associated with a history of early life stress, the study does not address how rumination develops as-a-habit in the first place. Other potential catalysts for rumination to consolidate as a mood-reactive habit have been suggested, such as cognitive inflexibility (Watkins & Nolen-Hoeksema, 2014), difficulties with attentional disengagement (Koster et al., 2011), and an imbalance in habit versus goal-directed behavior control (Ólafsson et al., 2020). Future research should strive to assess if the strength of the habitual association between NA and rumination changes longitudinally as a function of these potential moderators. The EMA assessment methodology utilized in the current study is ideally suited to test these novel predictions.

The findings of the study could have significant clinical implications. They provide a direct test of the habitual model of rumination that has not been tested empirically so far and reveal a potential vulnerability marker that could constitute an important mechanism of change during therapy. Rumination that is triggered with a high degree of automaticity might make it difficult for some people to fully recover from depression. Elevated rumination has been found to predict poorer outcomes following standard cognitive-behavioral therapy (Kertz et al., 2015). Preventive and acute therapy of depression may need to target the context-response association between negative mood and rumination and not just

the content of the ruminative thoughts. This is in line with the recent development of interventions specifically designed to target the habitual qualities of rumination, such as rumination-focused cognitive behavioral therapy (CBT; Watkins, 2018) and MBCT (Segal et al., 2018) where the ruminative response is specifically replaced with more helpful ways of responding (e.g., concrete thinking, compassion, mindfulness). Although rumination-focused interventions have found outcome effects that compare favorable to standard CBT (Hvenegaard et al., 2020; Teismann et al., 2014; Watkins et al., 2011) it remains to be seen whether they lead to greater reductions in rumination compared to other established treatments (Spinhoven et al., 2018).

The EMA measurement strategy used in the current study is also ideally suited to test whether interventions are successful in reducing the mood-reactive automaticity of ruminative thinking and to study mechanisms of change during therapy. Furthermore, the current findings suggest that rumination-focused interventions may be highly prescriptive for those with a history of childhood abuse. This is consistent with previous findings that MBCT provides additional protection over treatment-as-usual or placebo but only for those with a history of childhood abuse or adversity (Williams et al., 2014).

To sum up, the present results indicate that mood-reactive rumination may be a potential vulnerability marker for depression with rumination being habitually triggered in response to momentary fluctuations in negative mood with a high degree of automaticity. Habitual rumination may constitute a risk independent of the depressive course and originate in early life stress and abuse. Our findings suggest ways how depression vulnerability may emerge as a dynamic relationship between NA and rumination across time, not captured by traditional trait measures of rumination frequency. Future studies could expand on these findings by exploring whether targeting the mood-reactive automaticity of rumination as a mechanism of change during therapy can inform more personalized treatment selection and thereby reducing suffering and burden of depression.

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Received June 14, 2021

Revision received December 12, 2021

Accepted January 17, 2022 ■