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RESEARCH ARTICLE

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Like clouds in a windy sky: Mindfulness training reduces negative affect reactivity in daily life in a randomized controlled trial

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Abstract

While prior research has found mindfulness to be linked with emotional responses to events, less is known about this effect in a non-clinical sample. Even less is known regarding the mechanisms of the underlying processes: It is unclear whether participants who exhibit increased acceptance show decreased *emotional reactivity* (i.e., lower affective responses towards events overall) or a speedier *emotional recovery* (i.e., subsequent decrease in negative affect) due to adopting an accepting stance. To address these questions, we re-analysed two Ambulatory Assessment data sets. The first ($N_{Study1} = 125$) was a 6-week randomized controlled trial (including a 40-day ambulatory assessment); the second ($N_{Study2} = 175$) was a 1-week ambulatory assessment study. We found state mindfulness to be more strongly associated with emotional reactivity than with recovery, and that only emotional reactivity was significantly dampened by mindfulness training. Regarding the different facets of mindfulness, we found that the strongest predictor of both emotional reactivity and recovery was non-judgemental acceptance. Finally, we found that being aware of one's own thoughts and behaviour could be beneficial or detrimental for emotional recovery, depending on whether participants accepted their thoughts and emotions. Together, these findings provide evidence for predictions derived from the monitoring and acceptance theory.

KEYWORDS
acceptance, affect, ambulatory assessment, emotional reactivity, mindfulness

1 | INTRODUCTION

Negative affect (NA) is an important risk factor for poor mental and physical health (Pressman, Gallagher, & Lopez, 2013) and has been associated with elevated stress-associated salivary cortisol levels (Adam, Hawkley, Kudielka, & Cacioppo, 2006), as well as heightened risk of coronary events (Alan et al., 1999; Donker, 2000), diabetes (Carnethon, Kinder, Fair, Stafford, & Fortmann, 2003), arthritis (Kiecolt-Glaser, McGuire, Robles, & Glaser, 2002) and even cancer (Reiche, Morimoto, & Nunes, 2005). According to current clinical classification for mental disorders (DSM-5; American Psychiatric Association, 2013), NA is the critical diagnostic feature of depressive disorders.

Mario Wenzel and Zarah Rowland contributed equally to the manuscript.

In addition to these static measures of NA, research has increasingly examined the dynamic nature of affect, that is, its fluctuations over time. One important factor impacting these fluctuations is *emotional reactivity*—the extent to which individuals react to a stressful event with increases in NA. Research has highlighted the importance of NA reactivity, associating it with more depressive symptoms in adolescents (Silk, Steinberg, & Morris, 2003), as well as with an increased risk for both major depressive disorder (Bylsma, Morris, & Rottenberg, 2008) and generalized anxiety disorder in an adult population (Macatee & Cougle, 2013). This association has been explained by more excessive hypothalamic–pituitary–adrenal axis activations in response to stressful events (Kiecolt-Glaser et al., 2002).

Together, these findings indicate a strong correlation between emotional reactivity and negative health outcomes. With the understanding that lowering emotional reactivity might have strong positive effects on human health, and knowing that reducing NA reactivity has been identified as a key component of mindfulness training (Greeson et al., 2011), we here examine whether a brief mindfulness training can impact NA reactivity in daily life, and, if so, which facet of mindfulness is most associated with NA reactivity. We utilized data from two ambulatory assessment studies, one of which included a mindfulness training. This study design allowed us to obtain results of high ecological validity by capturing affective dynamics as they unfold in daily life (Wenzel & Kubiak, 2018).

Mindfulness is a complex construct that has been operationalized as both a state (Blanke & Brose, 2017) and a trait (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006), and as both a uni-dimensional (Brown & Ryan, 2003) and multidimensional concept with up to nine facets (Bergomi, Tschacher, & Kupper, 2014). Here, we built on prior research differentiating mindfulness into two facets (Bishop et al., 2004): acting with awareness (*awareness*; i.e., being aware of one's own behaviour and the present moment) and non-judgemental acceptance (*acceptance*; accepting thoughts and emotions without judging them).

According to the monitor and acceptance theory (Lindsay & Creswell, 2017), the combination of monitoring (*awareness*) and an accepting attitude (*acceptance*) contribute to improved well-being. During a breathing meditation session, individuals usually learn to focus their attention on a specific object, such as the breath, and the sensations that occur while breathing in and out. By monitoring momentary thoughts and feelings, individuals start to become aware of their momentary sensations instead of thinking about past or future events. If individuals monitor their thoughts and behaviours but also judge them negatively, monitoring can increase NA reactivity due to an increased focus on one's problems or suffering. However, when individuals adopt an accepting and non-judgemental stance towards their thoughts and feelings during this exercise, they disengage from negative states, resulting in lower emotional reactivity towards negative events (Lindsay & Creswell, 2017). Instead of judging one's feelings as being appropriate or inappropriate, mindfulness trainees learn to accept their feelings as they are, which allows them to experience feelings in a more balanced way, without over- or under-engaging with them (Desbordes et al., 2015).

Most research on mindfulness and NA reactivity has focused on populations with mental health diagnoses. For example, an 8-week mindfulness-based cognitive therapy program led to decreased NA reactivity in response to social stress in individuals with depression (Britton, Shahar, Szepsenwol, & Jacobs, 2012). Moreover, participants with borderline personality disorder reported lower levels of NA reactivity when randomly assigned to the mindfulness module of dialectical behaviour therapy compared to the control condition (Feliu-Soler et al., 2014). However, it is unclear whether a brief mindfulness training can also dampen NA reactivity in participants without psychiatric diagnoses. Thus, the first goal of the present research was to examine whether a brief mindfulness training can impact NA reactivity in daily life in a sample of undergraduate students.

The second goal of the present research was to examine how specific mindfulness facets relate to emotional reactivity. With regard to mean affect, prior research has shown that specific facets of mindfulness are differentially associated with affective well-being (see Blanke, Riediger, & Brose, 2018, for an extensive summary). For example, after an 8-week course of mindfulness-based cognitive therapy, while the facet of *attention* was associated with increased positive affect, *acceptance* was instead associated with decreased NA (Schroevers & Brandsma, 2010). In the same vein, the monitor and acceptance theory (Lindsay & Creswell, 2017) posits that attention without an accepting stance is positively associated with NA reactivity, while attention *with* an accepting stance is negatively associated with NA reactivity. Training *attention* only improved PA when participants also trained the *acceptance* component (Lindsay et al., 2018), and only the acceptance facet—not the awareness or attention facets—has been associated with less stress reactivity (Feldman, Lavalle, Gildawie, & Greeson, 2016) and emotional reactivity (Blanke et al., 2018). Thus, the second goal of the current manuscript was to provide more evidence on how both cultivating mindful states in daily life and undergoing mindfulness training are related to NA reactivity in daily life.

The third goal of the present research was to better understand how mindfulness can reduce the positive relationship between experiencing a negative event in daily life and responding to it with increased NA (Figure 1). As prior research on mindfulness training, affect and responses to adverse events has focused only on the time that has elapsed since the last measurement (Blanke et al., 2018), it is unclear whether the relationship between an event and affect is due to participants (a) having an accepting stance in general, and thus reacting less negatively towards adverse events (*reduced NA reactivity*; Figure 1) or (b) initially reacting strongly to the adverse event, but then adopt an accepting stance rapidly (*improved NA recovery*; Figure 1). Evidence for improved NA recovery can be found in laboratory research that reported dispositional mindfulness to predict greater recovery from NA but not reduced NA reactivity (Cho, Lee, Oh, & Soto, 2017). In the present research, we re-analysed two Ambulatory Assessment data sets to better differentiate between NA reactivity and NA recovery in daily life.

1.1 | Disclosures

We affirm that we reported all manipulations and exclusions in the studies presented here. However, we did not report all measures,

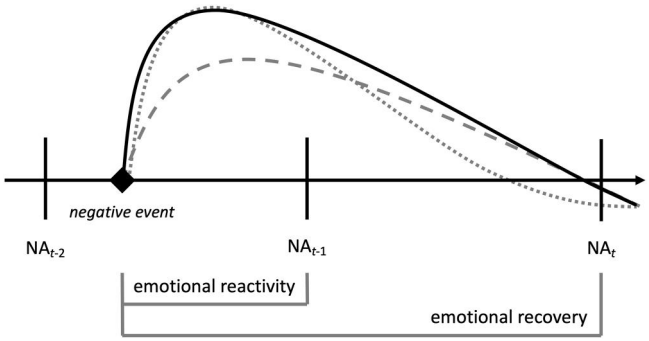

FIGURE 1 Operationalization of emotional reactivity and recovery. The black solid graph depicts the assumed average emotional response to negative events. The grey dashed graph shows a lower increase in negative affect in response to the negative event, that is, lower emotional reactivity. The grey dotted graph indicates a faster recovery from the negative event, that is better emotional recovery. NA, negative affect

because Study 1 was part of the registered SMASH study (https://clinicaltrials.gov/ct2/show/NCT02647801), which examined the effectiveness of a mindfulness intervention in influencing mindfulness, self-control and affective processes (Rowland, Wenzel, & Kubiak, 2019). Study 2 was part of a larger preregistered project on affect dynamics and regulation in romantic dyads (https://osf.io/dxpwm). The protocols were approved by the ethics committee of the Institute of Psychology at the Johannes Gutenberg University Mainz, Germany.

2 | STUDY 1

2.1 | Method

2.1.1 | Participants

The parent study block-randomly assigned 137 psychology students to the experimental and control condition, based on the power calculation ($d = 0.33$) for a small effect of mindfulness training on mindfulness. Participants were eligible if they were able to speak German and to provide informed consent and were between 18 and 65 years old. After 11 participants dropped out and one was excluded due to non-adherence (<33% completed assessments), 125 participants (77.6% female; M = 22.9 years, SD = 5.1 years) remained in the final sample. Participants received partial course credit and had the chance to win one of two 100 EUR voucher if they completed at least 80% of the assessments.

2.1.2 | Procedure

Study 1 implemented 7 weekly individual laboratory sessions that the participants attended individually, including one baseline session before any training had started (*t*0) and one end-of-training session (*t*6). Between pre- and post-assessments, participants in both the experimental and control condition completed a 40-day ambulatory assessment and attended 5 weekly training sessions (*t*1—*t*5). During these training sessions, participants were encouraged to ask any questions about the study that might increase adherence, such as sharing difficulties regarding the mindfulness training or ambulatory assessment protocol. Only participants in the experimental condition practiced mindfulness, completing a 12-min computer-based breathing meditation in each of the five training sessions (Levinson, Stoll, Kindy, Merry, & Davidson, 2014). In this task, participants focused on their breathing by pressing a specific key for breaths one through eight, and then a different key for breath nine. If they pressed the wrong key, they heard a sound and were instructed to re-focus on their breathing, accepting other thoughts and emotions as they might happen. Afterwards, they talked about their experiences during the task with the research assistant. Participants were also asked to practice mindfulness at home on a daily basis, by either listening to a breathing meditation (11 min) or by completing a body scan (23 min; please refer to the parent study for more information regarding home practice [Rowland et al., 2019]).

The day after the first laboratory session, participants received six signals on their smartphones for 40 consecutive days, prompting them to complete questionnaires regarding their emotions, recently experienced events, and level of mindfulness. Signals were randomly distributed between 10 AM and 8 PM using the experience sampling application movisensXS (movisens GmbH), with the time elapsed between two consecutive signals constrained to 45–200 min ($M = 103.4$ min, SD = 34.3). Adherence was good, with 75.9% completed assessments.

2.1.3 | Measures

Mindfulness

The aspect of mindfulness of acting with awareness (*awareness*) was assessed in Study 1 by selecting the three items from the state version of the Mindfulness Attention Awareness Scale (MAAS; Brown & Ryan, 2003) with the highest factor loadings (Items 8, 10 and 14). These items were rated on a 7-point scale Likert-type ranging from 0 (*not at all*) to 6 (*very much*) and then inverted, so that higher scores reflected higher levels of current awareness relative to the last observation ($M = 4.78$, SD = 1.31). Within-person reliability was good, with a within-person omega score of $\omega = 0.80$ (Geldhof, Preacher, & Zyphur, 2014). Please note that although the MAAS does not differentiate between awareness and present-moment attention, it mostly focuses on acting with awareness: For example, the acting with awareness facet of both the popular Five Facet Mindfulness Questionnaire (termed 'observing' there; Baer et al., 2006) and the Multidimensional State Mindfulness Questionnaire used in Study 2 (Blanke & Brose, 2017) are based on items from the MAAS.

Events

Participants were asked to think about the most negative event that had taken place since the last measurement and to rate how intense this event was on a slider ranging from 0 (*no negative event*) to 100 (*very negative event*), with higher scores indicating more intensely negative events ($M = 19.78$, $SD = 27.36$).

Negative affect

Current NA was assessed by averaging the responses to three items assessing anxiety, anger and sadness. The items were rated on a visual analogue scale ranging from 0 (*not at all*) to 100 (*very much*), with higher scores indicating more current negative affect ($M = 15.83$, $SD = 17.80$), $\omega = 0.58$.

2.1.4 | Analytic approach

NA reactivity

Following Koval et al. (2015), NA reactivity was operationalized via the association between the most negative event that had taken place between prompt *t* and *t*-1 and current NA at prompt *t*. With regard to the effect of the mindfulness training on NA reactivity (Study Goal 1), we used structural equation modelling (SEM) to account for underestimated associations due to measurement errors. The within-person standardized items assessing anxiety, anger and sadness loaded onto the latent variable of current NA, which was predicted by the three-way interaction between the effect-coded mindfulness training (-1 = control condition and 1 = mindfulness condition), the effect-coded week (-1 = pre-training and 1 = post-training) and within-person standardized recent negative event since the last observation (event between prompt *t* and *t*-1), controlled for the latent variable of prior NA and for the covariances between the error variance of the respective current and prior (lagged) emotion item. We chose within-person standardization over within-person centring, as recent research has demonstrated less biased results when between-person variance is present. This method also provides standardized effect sizes for easier interpretation (Wang et al., 2019). To test interactions, we adapted the double-mean-centring strategy (Lin, Wen, Marsh, & Lin, 2010) but standardized instead of centred the variables. Thus, all scale items were first within-person standardized, and the product of each within-person standardized measure comprising the interaction term was within-person standardized again after calculating the interaction.

With regard to state awareness (Study Goal 2), we predicted the latent variable of current NA by the two-way interaction between (a) most recent within-person standardized negative event since the last observation (event between prompt *t* and *t*-1) and (b) the latent variable of state awareness (consisting of three within-person standardized items), again controlling for the latent variable of prior NA and for covariances between the error variance of the respective current and prior (lagged) emotion item. The latent interaction variable consisted of the three within-person standardized products of the within-person standardized recent negative event, and of one of the three within-person standardized awareness items.

NA recovery

Again following Koval et al. (2015), NA recovery was operationalized via the association between the prior negative event between prompt *t*-1 and *t*-2 and NA at prompt *t*. Thus, NA recovery in daily life can be understood as a recovery process from one's initial reaction to an event, whereby NA returns to its baseline level. To examine the role of mindfulness in this process, we repeated the statistical analyses described for NA reactivity, but with the lagged *t*-1 version of the recent negative event.

Goodness-of-fit

In line with Hu and Bentler (1999), we assessed the fit of the SEMs using the chi-square-test, the Root Mean Square Error of Approximation (RMSEA), the Comparative Fit Index (CFI) and the Standardized Root Mean Squared Residual (SRMR). Given our sample size and data, we set cut-off values of ≤ 0.06 for the RMSEA and SRMR and >0.95 for the CFI (Byrne, 2001; Hu & Bentler, 1999).

Statistical power

To demonstrate the robustness of our results, we report the a posteriori power of each focal coefficient reflecting our research questions. Power was estimated by computing Monte Carlo simulations. For example, for the relationship between current awareness and NA reactivity, we simulated data based on 125 participants with 114 observations per participant (i.e., the mean number of negative events in Study 1). This number is lower than the average number of completed ambulatory assessment prompts after including lagged variables, for which the first observation of a given day must be excluded to produce a lag, and for which two successive completed ambulatory assessment prompts are needed. We then used the coefficients from the model on NA reactivity to predict current NA for the simulated sample. We repeated this procedure 1000 times and the a posteriori power is the percentage of how often a focal coefficient was significant in 1000 repetitions. Given the high statistical power we had, we also report standardized *p*-value p_{stan} in addition to significant *p*-values (Good, 1982; Lakens, 2018). P_{stan} takes the *p*-value and multiplies it by the square root of the number of participants or observations to adjust alpha due to the high power (Lakens et al., 2018).

2.2 | Results

Adherence to the study protocol was good, with each participant completing, on average, 182 of the 240 ambulatory assessment prompts ($M = 75.9\%$, $SD = 14.84$, range: 34.6%–97.5%). Moreover, participants reported a negative event (a value of at least 1 on the

TABLE 1 Fixed-effects estimates of latent current negative affect as a function of the mindfulness training, time (pre-vs. post-training) and events (between t and t-1), controlled for latent prior negative affect in study 1

	NA reactivity					NA recovery				
DV = current negative affect predictor	***B***	**SE**	***p***	**95% CI**	p_{stan}	***β***	**SE**	***P***	**95% CI**	p_{stan}
Mindfulness training	0.01	0.016	0.491	[−0.02, 0.04]	-	0.02	0.017	0.359	[−0.02, 0.05]	-
Time	−0.02	0.016	0.159	[−0.05, 0.01]	-	−0.04	0.017	0.027	[−0.07, 0.00]	0.179
Negative event	**0.39**	0.017	<0.001	[0.36, 0.43]	<0.001	0.00	0.023	0.930	[−0.05, 0.04]	-
Prior negative affect	**0.53**	0.020	<0.001	[0.49, 0.57]	<0.001	0.63	0.025	<0.001	[0.58, 0.68]	<0.001
Mindfulness training × time	−0.03	0.016	0.107	[−0.06, 0.01]	-	−0.02	0.017	0.373	[−0.05, 0.02]	-
Mindfulness training × negative event	**−0.04**	0.017	0.019	[−0.07, −0.01]	0.126	−0.05	0.018	0.009	[−0.08, −0.01]	0.060
Time × negative event	−0.02	0.017	0.232	[−0.05, 0.01]	-	0.04	0.018	0.017	[0.01, 0.08]	0.113
Mindfulness training × time × negative event	**−0.05**	0.017	0.004	[−0.08, −0.01]	0.027	0.02	0.018	0.191	[−0.01, 0.06]	-
Goodness-of-fit indices	χ^2 (33)	RMSEA	CFI	SRMR	Fit	χ^2 (33)	RMSEA	CFI	SRMR	Fit
Value	198.5	0.03	0.97	0.02	Yes	159.4	0.03	0.98	0.02	Yes

Note: mindfulness training, −1 = control condition, 1 = mindfulness condition; time, −1 = pre-training, 1 = post-training. Coefficients in bold do not include zero in their 95% confidence interval.

Abbreviations: CFI, Comparative Fit Index; DV, dependent variable; NA, negative affect, RMSEA, Root Mean Square Error of Approximation; SRMR, Standardized Root Mean Squared Residual.

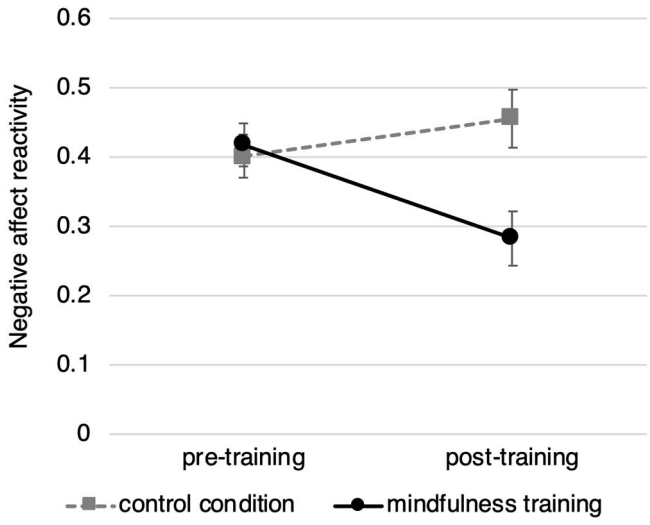

FIGURE 2 Estimated simple slopes showing the interaction between recent negative event, mindfulness training (control condition vs. mindfulness training), and week (pre-training vs. post-training) on momentary negative affect. Higher values indicate higher negative affect reactivity

scale ranging from 0 to 100) in 67.0% and a strong negative event (a value of at least 50 on the scale ranging from 0 to 100) in 16.9% of all 21,533 observations. Finally, as we previously reported, mindfulness training was effective in increasing both state and trait mindfulness, with participants in the mindfulness condition showing a highly significantly greater increase in both state and trait mindfulness over the course of the study than participants in the control condition (Rowland et al., 2019).

2.2.1 | Mindfulness training and NA reactivity and recovery

We first examined the effect of mindfulness training on NA reactivity (Study Goal 1). As indicated in Table 1, the model for NA reactivity yielded a significant three-way interaction, with an a posteriori power of 100% (i.e., 1000 significant simulated three-way interactions out of 1000 repetitions). As illustrated in Figure 2, only participants in the mindfulness training, $b = -0.13$, SE = 0.05, $p = 0.004$, 95% CI [−0.23, −0.04], but not in the control condition, $b = 0.05$, $SE = 0.05$, $p = 0.249$, 95% CI [−0.04, 0.15], showed reduced NA reactivity from baseline compared to the end of the training. With regard to NA recovery (Study Goal 2), Table 1 indicates that the three-way interaction was not significant, $\beta = 0.02$, power = 75.2%. Thus, we only found evidence for a small effect of the brief mindfulness training on NA reactivity, and no effect for NA recovery.

2.2.2 | Awareness and NA reactivity and recovery

In the next step, we turned to Study Goal 2 by investigating the relationship between state awareness and NA reactivity and recovery. As indicated in Table 2, the model for NA reactivity revealed a significant two-way interaction, with an a posteriori power of 100%: Higher levels of recent awareness than usual were associated with less NA reactivity, $b = 0.32$, $SE = 0.02$, $p < 0.001$, 95% CI [0.28, 0.36], compared to lower levels, $b = 0.43$, $SE = 0.02$, $p < 0.001$, 95% CI [0.40, 0.47]. Additionally, the model for NA recovery (Table 2) also yielded a negative two-way interaction (a posteriori power = 100%): Only participants with higher levels of recent awareness than usual

TABLE 2 Fixed-effects estimates of latent current negative affect as a function of the two-way interaction between negative event intensity and latent recent awareness, controlled for latent prior negative affect in study 1

	NA reactivity					NA recovery				
DV = current negative affect predictor	***β***	**SE**	***p***	**95% CI**	p_{stan}	***β***	**SE**	***p***	**95% CI**	p_{stan}
Negative event	**0.42**	0.010	<0.001	[0.40, 0.44]	<0.001	−0.02	0.014	0.155	[−0.05, 0.01]	-
Awareness	**−0.11**	0.011	<0.001	[−0.13, −0.09]	<0.001	−0.18	0.011	<0.001	[−0.20, −0.16]	<0.001
Prior negative affect	**0.46**	0.012	<0.001	[0.44, 0.49]	<0.001	0.57	0.016	<0.001	[0.54, 0.60]	<0.001
Negative event × awareness	**−0.04**	0.010	<0.001	[−0.06, −0.02]	<0.001	−0.04	0.011	<0.001	[−0.06, −0.02]	<0.001
Goodness-of-fit indices	χ^2 (53)	RMSEA	CFI	SRMR	Fit	χ^2 (53)	RMSEA	CFI	SRMR	Fit
Value	686.1	0.03	0.99	0.02	Yes	317.7	0.02	0.99	0.01	Yes

Note: Coefficients in bold do not include zero in their 95% confidence interval.

Abbreviations: CFI, Comparative Fit Index; DV, dependent variable; NA, negative affect, RMSEA, Root Mean Square Error of Approximation; SRMR, Standardized Root Mean Squared Residual.

reported significantly better NA recovery (i.e., less NA at observation *t*) after a negative event between observation *t*-1 and *t*-2, $b = -0.07$, SE = 0.02, $p < 0.001$, 95% CI [−0.11, −0.03] but not participants with lower levels than usual, $b = 0.03$, SE = 0.02, $p = 0.088$, 95% CI [−0.01, 0.07]. However, the interaction for NA recovery was not significant.

When entering both two-way interactions simultaneously, the coefficients were smaller but still significant, with $\beta = -0.04$, SE = 0.01, $p = 0.001$, 95% CI [−0.06, −0.01], $p_{stan} = 0.012$ for NA reactivity and $\beta = -0.02$, SE = 0.01, $p = 0.039$, 95% CI [−0.04, −0.001], $p_{stan} = 0.463$ for NA recovery (RMSEA = 0.04, CFI = 0.96, SRMR = 0.02).

2.3 | Discussion

The results of Study 1 demonstrate that the awareness facet of mindfulness was negatively associated with both NA reactivity and recovery. However, the brief mindfulness training significantly impacted only NA reactivity but not NA recovery. Thus, recent awareness was more strongly and more robustly associated with NA reactivity than with recovery, and both NA reactivity and NA recovery could be dampened by brief mindfulness training, although the effect sizes were small.

However, awareness is only one facet of mindfulness, aimed at capturing the attention component (Bishop et al., 2004). In Study 2, we wanted to replicate the results for awareness and examine another facet of mindfulness: non-judgemental acceptance. Furthermore, we wanted to test the hypothesis derived from the monitor and acceptance theory that monitoring and acceptance together dampen NA reactivity. For example, being more emotionally aware is connected to both greater alcohol use (Leigh & Neighbors, 2009) and more depressive symptoms (Desrosiers, Vine, Curtiss, & Klemanski, 2014)—but only if acceptance levels are low. Thus, awareness might only be beneficial for NA reactivity or recovery if accompanied by an accepting stance. If this stance is absent, being aware of one's thoughts and behaviours and judging them might be less adaptive, or even detrimental, due to an increased focus on one's own problems.

3 | STUDY 2

3.1 | Method

3.1.1 | Participants

The parent study recruited 90 romantic dyads (i.e., 180 participants), which could receive either partial course credit or 50 EUR (approx. US$ 57). After exclusions due to drop-outs and low adherence, 175 participants were included in the analyses (51.4% female; $M = 25.0$ years, SD = 5.4). Participants of Study 1 were not eligible for Study 2.

3.1.2 | Procedure

In the first lab session, participants provided informed consent and socio demographic information and were introduced to the movisensXS experience sampling application (movisens GmbH). Starting the next day, and for 7 subsequent days, participants received twelve signals per day, with consecutive signals at least 30 min apart (M = 58.3 min, SD = 20.6). Each couple could choose a daily start time of 9, 10 or 11 AM, which corresponded with an end time of 9, 10 or 11 PM, respectively. As in Study 1, adherence to the protocol was good (69.6%).

3.1.3 | Measures

Mindfulness

Study 2 used the *Multidimensional State Mindfulness Questionnaire* (MSMQ; Blanke & Brose, 2017) to assess mindfulness since the last observation point. This instrument employed two subscales—acting with awareness (*awareness*) and non-judgemental acceptance (*acceptance*) —with three items each. Scale items employed Likert-type ranges from 0 (*does not apply at all*) to 6 (*applies strongly*), with a mean of $M = 4.09$ (SD = 1.58) and a within-person reliability of ω =

0.82 for *awareness*, and a mean of $M = 5.00$ (SD = 1.25) and a within-person reliability of $\omega = 0.65$ for *acceptance*.

Events

Events were assessed as in Study 1, but on a scale ranging from 0 (*no negative/positive event*) to 6 (*very negative/positive event*), with a mean of $M = 0.75$ (SD = 1.41).

Negative affect

NA was also assessed as in Study 1, but on a scale ranging from 0 (*not at all*) to 6 (*very much*), with higher scores indicating more current negative affect ($M = 0.56$, SD = 0.89), $\omega = 0.58$.

3.2 | Results

As in Study 1, adherence to the study protocol was acceptable in Study 2: On average, participants completed 68.7% of the 84 possible signals (*SD* = 14.4, range: 34.5%–95.2%). Participants reported a negative event (a value of at least 1 on the scale ranging from 0 to 6) in 27.6% and a strongly negative event (a value of at least 4 on the scale ranging from 0 to 6) in 7.6% of all 10,080 observations.

3.2.1 | Mindfulness and NA reactivity and recovery

First, we sought to replicate the results for the relationship between state awareness and NA reactivity and recovery found in Study 1 (Study Goals 2 and 3). As illustrated in Table 3, the two-way interaction between latent within-person standardized recent awareness and manifest recent negative event (both between observations *t* and *t*-1) on latent current NA was not significant in Study 2 when acceptance was not entered into the model, with an a posteriori power of 29.1%. Moreover, NA recovery was also not significantly associated with awareness in Study 2 (power = 9.5%).

However, acceptance was significantly associated with NA reactivity (power = 100%): Participants with higher acceptance than usual (i.e., their own average) demonstrated lower levels of NA reactivity, $b = 0.05$, SE = 0.05, $p = 0.342$, 95% CI [−0.05, 0.15], than participants lower in acceptance, $b = 0.72$, SE = 0.05, $p < 0.001$, 95% CI [0.63, 0.82]. The coefficient of the two-way interaction between recent event and awareness was no longer negative but positive, such that participants who were more aware of their own thoughts and behaviours reported more reactivity to negative events, $b = 0.47$, SE = 0.04, $p < 0.001$, 95% CI [0.40, 0.55], than participants who were less aware, $b = 0.30$, SE = 0.04, $p < 0.001$, 95% CI [0.23, 0.38].

For NA recovery, only acceptance was significant, and this only when the *p*-value was not standardized (power = 99.7%): Participants who could better accept their thoughts and feelings than usual reported a significantly better recovery from negative events, $b = -0.06$, SE = 0.03, $p = 0.094$, 95% CI [−0.06, −0.001], than participants who had more difficulties with accepting these thoughts and feelings, $b = 0.08$, SE = 0.04, $p = 0.049$, 95% CI [<0.01, 0.16].

3.2.2 | Monitoring and acceptance theory and NA reactivity and recovery

Finally, we wanted to test the prediction derived from the monitoring and acceptance theory that monitoring is only beneficial if one adopts an accepting stance and is maladaptive if one monitors one's own thoughts and behaviour while judging them. One indicator for this relationship was that the negative association between awareness and NA reactivity reversed when attention and acceptance were entered into the model (Table 3), indicating that awareness was associated with higher NA reactivity. This result demonstrates that awareness can have detrimental consequences if the association with acceptance is controlled for. To test this notion more directly, we regressed the current NA on the three-way interaction between recent awareness, recent acceptance, and either recent negative event or its lagged *t*-1 version, and controlled for prior NA and current positive affect. Results did not indicate a significant three-way interaction for NA reactivity, $\beta = 0.02$, SE = 0.02, $p = 0.364$, 95% CI [−0.02, 0.05], power = 52.3%, but did indicate such an interaction for NA recovery, $\beta = -0.06$, SE = 0.02, $p = 0.003$, 95% CI [−0.10, −0.02], power = 99.9%, RMSEA = 0.04, CFI = 0.93, SRMR = 0.03. As indicated by the simple slope analysis in Figure 3, NA recovery became significantly worse with increasing levels of awareness when acceptance was lower than usual, $b = 0.18$, SE = 0.08, $p = 0.035$, 95% CI [0.01, 0.34], but significantly better when acceptance was higher than usual, b = -0.14, $SE = 0.06$, $p = 0.027$, 95% CI [−0.26, −0.02], RMSEA = 0.04, CFI = 0.94, SRMR = 0.03.

4 | GENERAL DISCUSSION

In the present research, we investigated the within-person relationships between mindfulness and emotional reactivity and recovery in daily life, and whether these relationships can be influenced by a brief mindfulness training. To our knowledge, this is the first study to show that emotional reactivity to negative events in daily life can be dampened via a brief mindfulness training in a sample without psychiatric diagnoses. Participants reported less NA increases in response to negative events after the training compared to the baseline, as evidenced by a small and significant effect size for NA reactivity. Thus, our results demonstrate that it is possible to design brief daily life interventions that foster improved NA reactivity in healthy individuals by guiding their attention to the present moment with an open and accepting stance. Consequently, a brief mindfulness training could be particularly useful for individuals under a lot of stress, such as nurses (Glazer & Gyurak, 2008) or university students (Stallman, 2010). Given the relatively low complexity and duration of our training, such mindfulness trainings could be relatively easy to integrate into, for example, university co-curricular programming.

With regard to NA reactivity, we found that the acceptance facet of mindfulness was the strongest predictor of NA reactivity, such that individuals who were more accepting of their inner

TABLE 3 Fixed-effects estimates of latent current negative affect as a function of the two-way interaction between negative event intensity and latent recent awareness and acceptance, controlled for latent prior negative affect in study 2

DV = current negative affect predictor	NA reactivity					NA recovery				
	β	SE	*p*	95% CI	p_{stan}	*β*	SE	*p*	95% CI	p_{stan}
Step 1: Awareness only										
Negative event	**0.42**	0.016	<0.001	[0.39, 0.45]	**<0.001**	**0.01**	**0.022**	**0.568**	[−0.03, 0.06]	-
Awareness	**−0.05**	0.018	0.006	[−0.08, −0.01]	**0.043**	**−0.08**	**0.019**	**<0.001**	[−0.11, −0.04]	**<0.001**
Prior negative affect	**0.43**	0.021	<0.001	[0.39, 0.47]	**<0.001**	**0.51**	**0.027**	**<0.001**	[0.45, 0.56]	**<0.001**
Negative event × awareness	−0.01	0.018	0.476	[−0.05, 0.02]	-	**−0.01**	**0.018**	**0.740**	[−0.04, 0.03]	-
Step 2: Awareness and acceptance										
Negative event	**0.34**	0.018	<0.001	[0.31, 0.38]	<0.001	0.01	0.022	0.637	[−0.03, 0.05]	-
Awareness	0.03	0.020	0.175	[−0.01, 0.07]	-	0.02	0.021	0.314	[−0.02, 0.06]	-
Acceptance	**−0.22**	0.023	<0.001	[−0.27, −0.18]	<0.001	−0.29	0.024	<0.001	[−0.34, −0.25]	**<0.001**
Prior negative affect	**0.40**	0.022	<0.001	[0.36, 0.44]	<0.001	0.45	0.028	<0.001	[0.39, 0.50]	**<0.001**
Negative event × awareness	**0.06**	0.020	0.003	[0.02, 0.10]	0.022	0.00	0.020	0.981	[−0.04, 0.04]	-
Negative event × acceptance	**−0.19**	0.023	<0.001	[−0.24, −0.15]	<0.001	−0.05	0.022	0.024	[−0.09, −0.01]	**0.177**
Goodness-of-fit indices	χ^2 (53)	RMSEA	CFI	SRMR	Fit	χ^2 (53)	RMSEA	CFI	SRMR	Fit
Step 1	**398.6**	**0.03**	**0.98**	0.02	Yes	**297.3**	**0.03**	**0.99**	0.02	Yes
Step 2	**877.9**[a]	**0.03**	**0.97**	**0.02**	Yes	**777.2**[a]	**0.03**	**0.97**	0.02	Yes

Note: p_{stan} = *p*-values multiplied by the square root of the number of observations to adjust alpha due to the high statistical power (Lakens et al., 2018).
Abbreviations: CFI, Comparative Fit Index; DV, dependent variable; NA, negative affect, RMSEA, Root Mean Square Error of Approximation; SRMR, Standardized Root Mean Squared Residual.
[a]df = 129.

experiences in a given moment than usual subsequently reacted less strongly to negative events. Awareness was less strongly associated with NA reactivity and became even detrimental when acceptance was also entered into the model in Study 2. Thus, awareness was only related to reduced NA reactivity following mindfulness training (Study 1), but this effect for *awareness* was not seen in participants who were not explicitly trained in mindfulness (Study 2). This suggests that mindfulness training may have a different impact on negative affect than trait mindfulness. For example, practicing mindfulness may increase acceptance, meaning that the relationship between awareness and NA reactivity in Study 1 could be linked to increased acceptance following mindfulness training. In turn, without mindfulness training, awareness may not be linked with an accepting stance and thus may not benefit NA reactivity.

This demonstrates that the association between awareness and NA reactivity can be attributed to acceptance rather than to awareness itself. These results replicate findings by Blanke et al. (2018), who found only the acceptance facet to be significantly associated with less NA reactivity in response to negative events. Our results also provide evidence for the monitor and acceptance theory (Lindsay & Creswell, 2017), which posits that awareness can have detrimental effects on emotional and health outcomes, depending on whether one is able to monitor one's own thoughts, emotions and behaviour with acceptance. Finally, these results show that the small effect of brief mindfulness training on NA reactivity may be amplified by focussing more on cultivating an accepting stance during breathing meditation.

One strength of our study was that we differentiated between two mechanisms whereby mindfulness can impact the positive association between experiencing a negative event and responding to it with increased levels of NA: Either by dampening the initial response to the negative event (i.e., NA reactivity) or by facilitating a quicker return to baseline NA levels (i.e., NA recovery). Overall, we found more robust evidence for the notion of decreased NA reactivity in daily life, as discussed earlier in this study. For NA recovery, the evidence was less clear: Although we found that both awareness in Study 1 and acceptance in Study 2 were associated with a faster recovery from the affective impact of negative events, the effect sizes in Study 2 were much smaller for NA recovery than for NA reactivity. Moreover, our brief mindfulness training in Study 1 did not significantly impact NA recovery. Thus, we can conclude that state mindfulness, especially acceptance, was most robustly associated with NA reactivity in both datasets.

Besides the positive association between awareness and NA reactivity in Study 2, we found additional support for the monitor and acceptance theory (Lindsay & Creswell, 2017), in that that both monitoring (awareness) and acceptance are important for health-relevant outcomes. In Study 2, we found that awareness was

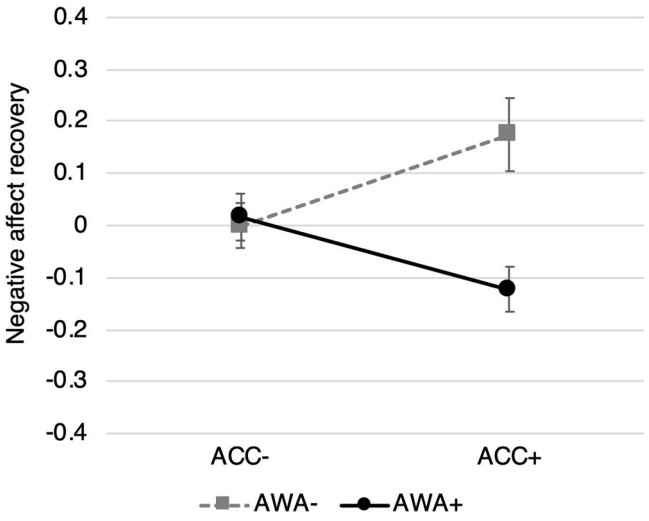

FIGURE 3 Estimated simple slopes showing the interaction of recent negative event, awareness (AWA), and acceptance (ACC) on momentary negative affect. Higher values indicate higher negative affect reactivity

differentially associated with NA recovery (but not NA reactivity) depending on acceptance, with awareness being significantly maladaptive for NA recovery if participants were less accepting than usual. In turn, awareness was significantly adaptive for NA recovery if participants were more accepting than usual. Thus, our results provide further evidence for the applicability of the monitor and acceptance theory in explaining how mindfulness is connected to NA recovery in daily life. Thus, mindfulness trainings should not only involve practicing monitoring one's own experiences but should emphasize doing so in an accepting way. This change would better provide individuals with the tools they need meet the difficult thoughts and emotions that they sometimes experience in their everyday life, potentially improving their well-being and health in the long run.

Our method for separating out NA reactivity and recovery was not optimal, given that we used signal-contingent assessments of events and affect. The item assessing affect was based on participants' emotions at the moment of assessment, whereas the item regarding negative events referred to the most intense event since the last prompt. Consequently, there was often a lag between the event and the assessment of its emotional response, making it more difficult to differentiate between reactivity and recovery. Similarly, the most recent negative event might not be the driving factor of current affect, but rather a much more intensely negative event that took place several hours earlier, and which participants would have been actively ruminating about. This might explain why we find a significant association between mindfulness and NA reactivity, but not between mindfulness and NA recovery, whereas prior laboratory research found the opposite effect (Cho et al., 2017). To address this gap, we recommend that future research utilize both laboratory and ambulatory measures of NA reactivity and recovery and employ a design better suited to capture contextual events (e.g., event-contingent designs), to gain a better understanding of how mindfulness influences the emotion generation and regulation process.

Additional study limitations include small effect sizes, which in some instances were very small. We suspect that a longer and more intense mindfulness training that focuses more strongly on the acceptance aspect could increase theses effect sizes. Moreover, although the effect size of the brief mindfulness training on NA reactivity in Study 1 was small, effects of such trainings on micro-processes such as NA reactivity are understood to be cumulative and may thus be important to improving health and well-being in the long run (Wichers, Wigman, & Myin-Germeys, 2015). Second, participants in Study 1 were mostly young females in their 20s, limiting generalizability of these findings. However, the sample for Study 2 had an almost even gender distribution and included more participants that were not undergraduate students of psychology. Still, this sample should not be considered representative of the general population, and future research would be best served by seeking out diverse and representative samples. Finally, it is important to acknowledge that our results in Study 2 are based on the mindfulness operationalization of the MSMQ and, that it is thus unclear whether acceptance will remain the central mindfulness facet once other facets such as curiosity, decentring (Lau et al., 2006), description, or non-reactivity (Baer et al., 2008) are adequately explored. Deciding which facets are central to mindfulness is beyond the scope of the present article, but we agree with prior research that it is important that any research on mindfulness clearly state which facet it is focused on (Van Dam et al., 2018).

Taken together, our findings demonstrate that mindfulness, especially its acceptance facet, is significantly associated with less NA reactivity to negative events in daily life, which can be facilitated by a brief mindfulness training.

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CONFLICT OF INTEREST

The authors have declared that they have no conflicts of interest.

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