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BRIEF MINDFULNESS INTERVENTIONS IN DAILY LIFE: EFFECTS ON REPETITIVE NEGATIVE THINKING AND AFFECT

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SUMMARY

Repetitive negative thinking (RNT) is a problematic thinking style that encompasses rumination and worry. RNT is characterized by continuously dwelling on negative content, such as problems or unpleasant experiences. RNT is associated with negative affect and various psychopathological symptoms, and it even predicts the onset of these symptoms, making it a transdiagnostic risk factor for psychopathology. This qualifies RNT as an ideal candidate for interventions because its reduction can help avoid worsened affect and symptoms, and may even prevent psychopathology.

Mindfulness interventions are promising to reduce RNT because mindfulness teaches us to become aware of experiences (e.g., thoughts and feelings) and approach these experiences in an observing and non-judgmental way instead of getting stuck in negativity. Previous findings suggest that mindfulness interventions may indeed be helpful to reduce RNT and symptoms, and to improve affect. However, it remains largely unanswered whether brief mindfulness interventions in daily life lead to immediate benefits for RNT and affect. Two randomized controlled trials were conducted as part of this dissertation to answer this question. In both studies, participants completed brief audio-guided mindfulness interventions multiple times per day over several days. Immediately after each intervention, participants reported their RNT and affect via experience sampling method (ESM).

STUDY 1 investigated the effects of a mindfulness intervention in N = 91 non-clinical participants. Over 10 days, participants were randomized at each assessment to complete either a mindfulness intervention or an active control task consisting of listening to neutral background sounds. Results of STUDY 1 showed that participants reported less RNT and less negative affect after completing the mindfulness intervention as compared to the control condition. However, the associations between RNT and negative affect were not impacted by the mindfulness intervention.

STUDY 2 investigated the effects of a detached mindfulness intervention in *N* = 100 participants with elevated trait RNT. The study consisted of a 5-day baseline phase with only ESM assessments and a 5-day intervention phase, where participants additionally engaged in either a detached mindfulness or an active control task, depending on which group they were randomized to. The control task was matched to the mindfulness intervention except for the mindfulness instructions and corresponded to a guided imagery task. Results of STUDY 2 showed that participants of both groups reported stronger reductions in RNT and in negative affect, and stronger improvements in positive affect during the intervention phase compared to the non-intervention baseline phase. However, there were no differences between the groups.

The integration of the studies' findings allows to draw conclusions about the effectiveness of mindfulness interventions and about the mechanisms causing benefits.

Effectiveness. Findings suggest that detecting an effect of the mindfulness interventions depended on the control condition used as a comparison. Our guided mindfulness interventions led to less RNT and negative affect compared to both (i) not engaging in any task (STUDY 2) and (ii) listening to neutral background sounds (STUDY 1). However, the mindfulness intervention was equally effective as a matched control task that excluded mindfulness instructions (i.e., guided imagery; STUDY 2).

Mechanisms. The studies of this dissertation do not allow us to conclusively determine which mechanisms caused the benefits across both mindfulness interventions and the guided imagery task. It could be that experiencing momentary mindfulness led to lower RNT and better affect. However, other mindfulness-unspecific mechanisms, such as expectations about the helpfulness of the tasks or distraction from current RNT and affect, may also have been (partly) responsible for the observed benefits.

Overall, findings of this dissertation indicate that brief guided mindfulness interventions and guided imagery tasks are helpful to immediately reduce RNT and improve affect in daily life. Whether these tasks caused benefits by increasing momentary mindfulness or via other mechanisms remains to be elucidated.

CONTENTS

CHAPTER 1

INTRODUCTION

Every day, thousands of thoughts wander through our minds. It is natural that some of them are negative. However, such thoughts can become a problem when they persist, circle around issues over and over, and stopping this circle seems almost impossible. Such a thinking pattern is known as repetitive negative thinking (RNT) and encompasses rumination and worry (Ehring & Watkins, 2008). RNT is associated with various emotional problems and symptoms, such as increased negative affect and anxiety (Aldao et al., 2010; Vîslă et al., 2022). RNT is a common symptom reported by individuals with different mental disorders which qualifies it as transdiagnostic (Ehring & Watkins, 2008; Lincoln et al., 2022; Wahl et al., 2019). It also plays a significant role in the onset of mental disorders (Nolen-Hoeksema et al., 2008). Therefore, RNT contributes to psychopathology in two ways – as a symptom and as a risk factor. The good news is, targeting RNT then allows for both, the treatment and the prevention of psychopathology.

One potential way to reduce RNT is mindfulness. Mindfulness aims to become aware of and approach experiences in an observing and non-judgmental way (Bishop et al., 2006; Lindsay & Creswell, 2017). Thereby, it may be an antidote to RNT which is characterized by rigid attention to negativity. Previous findings suggest that mindfulness may indeed be promising to reduce RNT and to improve affect or symptoms (e.g., Leyland et al., 2019; Mao et al., 2023). However, previous investigations mostly studied the causal effects of whole mindfulness treatment programs on measures assessed at post-treatment. This does not speak to the immediate effects of mindfulness, however. Other investigations have assessed the causal effects of brief mindfulness interventions delivered in the laboratory. These findings may not generalize to daily life due to the unnatural conditions in the laboratory.

Therefore, it remains largely unknown how brief mindfulness interventions conducted in an everyday life context impact RNT and emotional experiences immediately after. In other words, does engaging in a brief mindfulness intervention lead to immediate benefits for RNT and affect in daily life? This dissertation aims to answer this question by integrating brief mindfulness interventions into the daily lives of participants and assessing the immediate impact of these interventions on momentary RNT and affect.

1.1 REPETITIVE NEGATIVE THINKING (RNT)

1.1.2 WHAT RNT IS

RNT is to be absorbed in negative thinking. Thoughts come to mind seemingly unbidden, the mind circles around them over and over, and gaining control over the thinking seems almost impossible. A prominent form of RNT is rumination. Rumination derives from the Latin word *rūminātio* meaning "chewing the cub" (German: "wiederkäuen"; 'Rumination', 2023), aptly illustrating its nature. Similar to a cow regurgitating and rechewing grass, the same issues return to a person's mind and are revisited again and again. Rumination was initially studied in the context of depression where it was defined as thoughts that repetitively focus attention on negative emotions and symptoms, their causes, and consequences (Nolen-Hoeksema, 1991). The content of such ruminative thoughts would primarily focus on negative aspects of the self or the past (Teismann & Ehring, 2019). It was theorized that responding to negative emotions by brooding about questions like "Why do I feel sad?" or "Why am I such a failure?" exacerbates depressive symptoms (Nolen-Hoeksema, 1991). Subsequent research revealed that rumination is not only present in depression but also in other mental disorders, such as Generalized Anxiety Disorder (GAD; American Psychiatric Association, 2013) and Social Anxiety Disorder (SAD; American Psychiatric Association, 2013; McEvoy et al., 2013). Additionally, there were other thinking patterns that were each linked to specific disorders but that closely resembled depressive rumination. In SAD, for example, individuals would reiterate past social situations thinking about possible failures or embarrassments, a thinking called post-event processing (Clark & Wells, 1995). In GAD, individuals would anxiously think about upcoming events with potentially negative outcomes, a thinking called worry (Borkovec et al., 1998). Hence, across disorders, people get absorbed in negative thinking.

This led to the conceptualization and definition of RNT as a transdiagnostic construct encompassing the different repetitive thinking patterns across disorders (Wahl et al., 2019). Here, RNT is defined as "thinking about one's problems (current, past, or future) or negative experiences (past or anticipated)" that is: a) repetitive, b) intrusive, c) difficult to control (Ehring et al., 2011, p. 226). Additionally, the thinking is often perceived as unproductive and as consuming mental energy (Ehring et al., 2011). Thus, thoughts may unintentionally enter one's mind and circle around an issue without one being able to exit this pattern. This thinking is perceived as exhausting, while simultaneously not helping to get anywhere. Importantly, in this definition, RNT is characterized by its process features – the "how" of the thinking –, not the specific content of thoughts (Ehring et al., 2011). That means that individuals across different disorders may engage in RNT as a thinking style, but the content of their thoughts may vary based on the specific disorder and individual experiences (Ehring, 2021).

In sum, RNT is a problematic thinking style characterized by repeatedly thinking about negative content that is perceived as uncontrollable and unproductive. It subsumes more disorder-specific forms of cycling thinking such as rumination. RNT is transdiagnostic because it is prevalent across different disorders.

1.1.3 WHY REDUCING RNT IS IMPORTANT

RNT plays a significant role in shaping our emotional experiences and how we interact with the world. This has been demonstrated by data collected cross-sectionally, longitudinally, in experimental lab studies, and in daily life. Specifically, RNT has been robustly related to psychopathology.

1.1.3.1 RNT is Positively Related to Symptoms

RNT is related to various unfavorable outcomes cross-sectionally as shown by multiple meta-analyses. RNT has been positively related to symptoms of anxiety and depression (Aldao et al., 2010; Vîslă et al., 2022) as well as eating disorders and substance-related symptoms (Aldao et al., 2010) in both clinical and non-clinical populations. RNT has also been associated with lower well-being, including reduced positive emotions and life satisfaction, among individuals with various mental disorders, such as depression, anxiety, eating, and personality disorders (Kraiss et al., 2020). Additionally, RNT has been related to more severe symptoms of depression, anxiety, aggression, and addiction in children and adolescents (Kraft et al., 2023), poorer sleep quality in non-clinical populations (Clancy et al., 2020), and deficits in discarding no longer relevant material from working memory (Zetsche et al., 2018).

In sum, metanalyses of cross-sectional studies demonstrate that RNT is positively related to various emotional and behavioral symptoms across both clinical and non-clinical populations. In addition to cross-sectional associations, longitudinal studies provide insight into how RNT predicts future symptoms.

1.1.3.2 RNT Predicts Future Symptoms

RNT prospectively predicts symptoms of psychopathology as shown by longitudinal studies accompanying participants from months to several years. RNT was shown to predict the *onset* of significant depressive symptoms (Just & Alloy, 1997) and major depressive episodes (Nolen-Hoeksema, 2000; Nolen-Hoeksema et al., 2007). This suggests that relatively healthy individuals who experience higher levels of RNT are at higher risk for developing depressive symptoms in the future. Evidence on how RNT is related to the *duration* of depressive symptoms is less consistent (see Nolen-Hoeksema et al., 2008 for a discussion of pro and contra evidence). Thus, there is robust evidence that RNT predicts the onset of depressive symptoms in previously non-depressed individuals but, once symptoms have manifested, does not always predict their duration. The role of RNT in the onset of psychopathology underscores the importance of intervening early with the goal of reducing RNT and thereby preventing individuals from transitioning into full-blown psychopathology. Consequently, interventions should also be effective for individuals below the threshold of psychopathology. Such interventions could function as preventive interventions.

Longitudinal studies have further demonstrated that RNT also precedes symptoms of other disorders. RNT predicted the onset and increase of eating disorder problems, substance abuse in female adolescents (Nolen-Hoeksema et al., 2007), and suicidal ideation (Smith et al., 2006). Moreover, RNT was shown to predict anxiety (Sarin et al., 2005; Segerstrom et al., 2000) and posttraumatic stress symptoms (Nolen-Hoeksema & Morrow, 1993).

In sum, longitudinal studies show that RNT temporally precedes various symptoms of psychopathology. Particularly noteworthy is the robust evidence indicating that RNT predicts the onset of depression. Findings from experimental laboratory (lab) studies can extend this knowledge by revealing the causal impact of RNT on experiences.

1.1.3.3 RNT Worsens Affect and Increases Symptoms in the Lab

RNT worsens individuals' affect and symptoms as shown by experimental lab studies. Typically, these studies induce negative affect in participants by instructing them to recall a negative event or by exposing them to distressing stimuli, followed by instructions to engage in RNT.

Findings show that ruminating about the negative event is related to worsened affect as compared to conditions such as distraction or reappraisal (Denson et al., 2012; Peuters et al., 2019; Zetsche et al., 2009). Additionally, RNT has been shown to increase negative affect, anxiety, and depression (McLaughlin et al., 2007). However, this study solely compared worrying to ruminating about issues, revealing a similar negative impact for both forms of RNT. Yet, these findings do not shed light on how these forms of RNT differ from other control conditions.

Many early investigations compared how rumination impacts individuals with low vs. elevated levels of depression. These studies revealed that instructing participants to focus on emotions, their causes and consequences led to increased negative affect only among those with elevated depressive symptoms (e.g., Lyubomirsky et al., 1998; Nolen-Hoeksema & Morrow, 1993). The authors argue that the instructed repetitive self-focus only exacerbates negative affect in individuals with elevated levels of depression because they “have more negative feelings and cognitions” that the thinking then concentrates on (Nolen-Hoeksema et al., 2008, p. 402). Together these experimental studies show that repetitively thinking about something negative, whether it is an experimentally induced negativity or a naturally occurring one, worsens affect and increases symptoms. That is, RNT causes feeling worse.

While these experimental lab studies allow for causal inference, their downside is the potentially limited ecological validity due to their controlled environment. Studies using experience sampling methodology investigate RNT and its relation to experiences in a natural context.

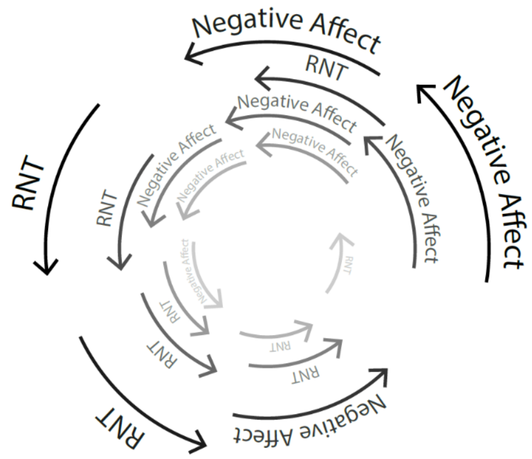
1.1.3.4 RNT is Related to Worse Affect in Daily Life

Experience sampling methodology (ESM) allows insight into individuals’ real-time experiences in a real-life context (Myin-Germeys & Kuppens, 2022). Typically, an ESM study prompts participants to report their momentary experiences multiple times per day using a smartphone app. A major advantage of ESM is the direct assessment of experience in a natural environment. This reduces recall bias and provides ecologically valid data (Csikszentmihalyi & Larson, 1987; Myin-Germeys & Kuppens, 2022).

ESM studies underline the crucial role of RNT in shaping emotional experiences. Specifically, RNT appears to trigger a spiral of negativity that arises as follows. First, RNT and negative affect are concurrently associated. Thus, experiencing stronger RNT at one moment is associated with experiencing stronger negative affect at the same moment (Kircanski et al., 2018). Second, RNT and negative affect bi-directionally amplify each other over time. Thus, stronger momentary RNT increases negative affect at the next moment (Blanke et al., 2022; Selby et al., 2016; Stefanovic et al., 2021; Zetsche et al., 2023). Deteriorated affect can again trigger stronger RNT (Blanke et al., 2022; Hjartarson et al., 2021; Selby et al., 2016; Stefanovic et al., 2021). In addition to these bi-directional associations, RNT and negative affect tend to persist over time – a process called inertia (Koval et al., 2021). Thus, the level of RNT (Bean et al., 2020; Blanke et al., 2022; Selby et al., 2016) and negative affect (Blanke et al., 2022; Koval et al., 2021) at one moment predict their levels at the next moment. Collectively, these associations form an unfavorable pattern: RNT and negative affect dynamically interact, fueling a spiral of negativity wherein negative experiences perpetuate themselves over time (see Figure 1; Garland et al., 2010).

Figure 1

Spiral of Negativity Where RNT and Negative Affect Perpetuate Themselves and Each Other Over Time



On a micro-level, this spiral might even act as a building block of mental disorders (Garland et al., 2010). Indeed, Stefanovic et al. (2021) found that individuals with stronger associations between RNT and negative affect – and who additionally experienced higher negative affect in daily life – were at increased risk for developing depressive symptoms in the future. Additionally, greater moment-to-moment persistence in RNT (Bean et al., 2020, 2021) and negative affect (Houben et al., 2015) have been linked to psychopathology. In other words, individuals who have a more densely connected spiral of negativity tend to report higher levels of psychopathology.

In sum, ESM studies reveal the detrimental role that RNT plays in how we feel in everyday life. Especially, RNT may build a spiral of negativity in interplay with negative affect. This spiral can make individuals feel worse and may even be a breeding ground for psychopathology.

Overall, numerous studies investigating RNT with different study designs demonstrate its detrimental role in mental health, affecting both clinical populations and healthy individuals. Studies suggest that RNT is a risk factor for various symptoms of psychopathology and has an immediate negative impact on how we feel.

Consequently, reducing RNT and its impact on negative experiences promises to alleviate symptoms and potentially even prevent full-blown psychopathology.

Different approaches can be considered to modify RNT (for an overview see: Teismann & Ehring, 2019; Topper et al., 2010). For example, RNT can be addressed by changing the thought *content* as through cognitive restructuring in Cognitive Behavioral Therapy (Beck, 2011). Alternatively, RNT can be addressed by changing a person's relationship to their thoughts. This is the aim of mindfulness. Given that RNT is marked by a detrimental way of relating to thoughts, mindfulness emerges as a particularly suitable candidate to tackle RNT.

1.2 MINDFULNESS

1.2.1 WHAT MINDFULNESS IS

Mindfulness can be defined as attending to the present moment with openness, curiosity, and acceptance (Bishop et al., 2006). There is no single definition of mindfulness and there is no overall agreement on "what this thing mindfulness is" (Goto-Jones, 2024, Module 2; Van Dam et al., 2018). However, a uniting feature of most conceptualizations is that mindfulness encompasses (1) attention to present moment experiences that is (2) accompanied by a certain attitude towards these experiences (Lindsay & Creswell, 2017).

Mindfulness may describe a person's general tendency to be mindful (i.e., trait mindfulness), the level of mindfulness experienced at a specific moment (i.e., state or momentary mindfulness), and it can describe a practice (i.e., mindfulness intervention; Van Dam et al., 2018). Within this dissertation, mindfulness primarily refers to mindfulness as a state and as a practice. Specifically, the studies in this dissertation use a mindfulness intervention to cultivate momentary mindfulness and to then assess the consequences of this mindfulness state on experiences.

To get a more profound understanding of what mindfulness is, it can be helpful to imagine its opposite – mindlessness. Mindlessness can also be understood as being on autopilot (Kabat-Zinn & Hanh, 2009). When being on autopilot, we go through life "functioning mechanically, without being fully aware of what we are doing or experiencing." (Kabat-Zinn & Hanh, 2009, p. 21). Importantly, being on autopilot may keep us trapped in automatic, unbeneficial reactions to experiences (Segal et al., 2002). For example, a negative emotion like sadness may trigger a person with depressive symptomatology to brood about why they feel so sad and worry about whether they will ever feel happy again. This may pull them into the spiral of negativity, and make the person feel worse and worse. Mindfulness can be seen as an antidote to such an automatic functioning: It increases awareness about our experiences and reactions and offers a different way of relating to them (Kabat-Zinn & Hanh, 2009; Segal et al., 2002). Instead of getting trapped in a spiral of negativity, the person with the sad feelings may approach their experiences mindfully by acknowledging that the sad feeling is present but refraining from judging both the feeling and their thinking about it as negative or unwanted and trying to just observe and accept whatever feelings and thoughts are present.

Many mental disorders are characterized by unfavorable, often automatic reactions to experiences as well as negative judgments of feelings and behaviors (American Psychiatric Association, 2013). RNT is a prime example. It is characterized by rigid attention to thoughts accompanied by negative judgments (Ehring & Watkins, 2008; Wells, 2011). Mindfulness is thought to offer a pathway out of these detrimental patterns by enabling individuals to become aware of how they attend to experiences, and by teaching them to choose how to respond, rather than reacting on autopilot (Segal et al., 2002).

The assumed beneficial effects of mindfulness have led to its integration into different interventions and treatment programs. Treatment programs that use mindfulness as their main form of treatment can be referred to as mindfulness-based interventions (MBIs; Groves, 2022). They typically consist of a “package” of mindfulness practices, that are administered over multiple weekly sessions in a group setting. Mindfulness-based stress reduction (MBSR; Kabat-Zinn & Hanh, 2009) and mindfulness-based cognitive therapy (MBCT; Segal et al., 2002) are the two most widely adopted and investigated MBIs.

Another treatment program that is not generally grounded in mindfulness but partially applies the principle of mindfulness, is metacognitive therapy. RNT is a main contributor to psychopathology according to the theory of metacognitive therapy, especially due to the spiral of negativity it creates together with negative affect (Wells, 2011). Therefore, it is a major goal of metacognitive therapy to interrupt RNT. To do so, it applies the principle of mindfulness within an intervention called detached mindfulness (Wells, 2011). Detached mindfulness teaches us to notice one’s thoughts while refraining from evaluating their content, or reacting to them by for example suppressing them. Additionally, detached mindfulness encourages us to realize that thoughts are spontaneous, transient events that do not represent absolute truths. As such, detached mindfulness invites individuals to view themselves as a non-judgmental observer, detached from their thoughts.

Detached mindfulness as originating from metacognitive therapy shares many characteristics with mindfulness within MBIs, yet there are some differences. Both intend to shift attention to present-moment experiences without attempting to change them (Medvedev et al., 2022; Wells, 2011). Detached mindfulness solely directs attention toward current thoughts, however, while mindfulness interventions within MBIs may direct attention toward a broader range of experiences, such as emotions or sensations (Kabat-Zinn & Hanh, 2009; Wells, 2011). A crucial part of detached mindfulness is to achieve a metacognitive perspective by perceiving thoughts as detached from the self (Wells, 2011). MBIs do not always include detachment from experiences (Van Dam et al., 2018). In essence, detached mindfulness falls within the broader framework of mindfulness but is narrower and more specific than the forms of mindfulness that may be applied in MBIs. In other words, a detached mindfulness intervention may be equally used within MBIs but some interventions of MBIs fall outside the boundaries of detached mindfulness as conceptualized within metacognitive therapy.

In sum, mindfulness encompasses bringing non-judgmental attention to present-moment experiences. Mindfulness within MBIs is applied to a variety of experiences, such as feelings, sensations, and thoughts. Detached mindfulness within metacognitive therapy more specifically aims at a detached and non-judgmental observation of thoughts.

Both studies of this dissertation investigate the effects of a mindfulness intervention. STUDY 1 uses a mindfulness intervention that may be part of MBI treatment programs; STUDY 2 uses a detached mindfulness intervention that may be part of metacognitive therapy.

1.2.2 WHY MINDFULNESS IS PROMISING

Mindfulness is positively linked to mental health. On the one hand, studies demonstrate that state and trait mindfulness correlate with mental health measures. On the other hand, intervention studies reveal the causal effect of mindfulness practices on mental health outcomes.

1.2.2.1 Mindfulness is Related to Less RNT, Less Symptoms, and Better Affect

Both one’s general tendency to be mindful (i.e., trait mindfulness) and experiencing mindfulness at a certain moment (i.e., state or momentary mindfulness) are related to better mental health.

Individuals who report higher levels of trait mindfulness report less trait RNT as shown by a systematic review (Tomlinson et al., 2018). Additionally, individuals who tend to be more mindful report fewer symptoms of anxiety, depression, post-traumatic stress disorder, and GAD as shown by a meta-analysis (Carpenter et al., 2019). Trait mindfulness has also been linked with lower inertia of negative affect (Keng & Tong, 2016; Rowland et al., 2020), meaning that the negative affect of individuals with higher trait mindfulness persists less from one daily life moment to the next.

Further, state mindfulness is associated with better momentary experiences as shown by ESM studies. For example, state mindfulness was associated with lower momentary RNT and negative affect (Blanke et al., 2018, 2020; Brown & Ryan, 2003). Moreover, Blanke et al. (2020) reported that the within-person association between RNT and negative affect was attenuated when individuals reported higher levels of momentary mindfulness. Thus, at moments with higher mindfulness, the effect of RNT on negative affect was decreased, indicating less triggering among the spiral of negativity.

In sum, individuals reporting higher trait and state mindfulness exhibit less RNT, fewer symptoms, and lower associations between RNT and negative affect. Intervention studies supplement this knowledge about association by revealing the causal effect of mindfulness.

1.2.2.2 Mindfulness Interventions Reduce RNT, Reduce Symptoms, and Improve Affect

Mindfulness interventions have been shown to reduce RNT, reduce symptoms, and improve affect. Evidence comes from different types of studies: Randomized controlled trials (RCTs) of mindfulness treatment programs, experimental lab studies, and studies implementing a mindfulness intervention in daily life.

1.2.2.2.1 Mindfulness treatment programs reduce RNT and symptoms

RCTs show that the package of mindfulness interventions that MBIs include is effective as a whole. Two meta-analyses demonstrate that MBIs reduced RNT similarly to cognitive behavioral therapies (Mao et al., 2023; McCarrick et al., 2021). Additionally, digital MBIs reduced RNT more strongly than active and passive control conditions as shown by a systematic review (Vargas-Nieto et al., 2024). Often, however, the effects of MBIs appear to be smaller and less often significant when they are compared to active instead of passive control conditions (Goldberg, 2022). This is not surprising (see Chapter 4.2 for reasons) but underlines that observed effects always have to be interpreted in the light of the control conditions that mindfulness is compared to.

Metacognitive therapy as a whole – hence, a treatment program including detached mindfulness but also interventions unrelated to mindfulness[1] – also reduced worry, anxiety, and depressive symptoms compared to either a waitlist or active control condition as shown by a meta-analysis (Normann & Morina, 2018; note, however, that this meta-analysis also included non-randomized studies). In a newer RCT not included in the meta-analysis, metacognitive therapy led to improvements in RNT as well as in symptoms of depression and anxiety compared to a waiting-list condition (Hjemdal et al., 2019).

Detached mindfulness has also been investigated as a separate intervention, thus, independently from other interventions of metacognitive therapy. Detached mindfulness led to stronger reductions in anxiety (Ahmadpanah et al., 2017) as well as stronger (Ahmadpanah et al., 2017) or similar (Ahmadpanah et al., 2018) reductions in depressive symptoms than active control interventions.

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1 Interventions in metacognitive therapy that are unrelated to mindfulness include those targeting metacognitions. For instance, a person might hold the positive metacognitive belief that "Thinking this through helps me understand my problem." One objective of metacognitive therapy is to help the person recognize that such "thinking through" (i.e., RNT) is not beneficial and can instead worsen their feelings. The interventions employed to facilitate this realization are not based on mindfulness principles. See Hansmeier & Exner (2020) for a compact overview of all interventions utilized in metacognitive therapy.

In sum, MBIs, metacognitive therapy, and detached mindfulness as a specific intervention of metacognitive therapy were shown to reduce RNT and symptoms. Such RCTs illuminate the causal effects of treatments on post-treatment measures, with post-treatment measures referring to outcomes that are assessed once no more interventions are delivered. Hence, those studies provide insight into the overall effect of multiple weeks of treatment which is represented by a questionnaire score assessed after treatment completion. Experimental lab studies extend this knowledge by revealing the effect of brief mindfulness interventions on immediate outcomes.

1.2.2.2.2 Mindfulness reduces RNT and improves affect in the lab

Experimental lab studies show that mindfulness leads to immediate improvements in RNT and emotional patterns. A meta-analysis showed that single mindfulness interventions – which can be thought of as mindfulness inductions – reduced RNT and negative affect (Leyland et al., 2019). However, the results depended on the control induction. Specifically, there were no differences when mindfulness was compared to distraction. This suggests that, at least under lab conditions and for immediate outcomes, it does not matter whether participants approached their experiences mindfully or distracted themselves.

Some studies also demonstrated the causal benefits of brief detached mindfulness interventions. Single sessions of detached mindfulness improved RNT (Gkika & Wells, 2015) as well as the perceived controllability and distress of one's thoughts (Caselli et al., 2016) more strongly than active control conditions. Another study delivered a detached mindfulness intervention in the lab and assessed its effects with daily measures afterward. It showed that detached mindfulness reduced RNT and made participants rate their RNT as more controllable and less distressing as compared to a passive control group (Modini & Abbott, 2018).

In sum, brief mindfulness interventions in the lab improve RNT, its appraisal, and emotional outcomes. The insights from studies employing such experimental designs are valuable because they illuminate whether manipulating participants' momentary mindfulness via a specific mindfulness intervention can help immediately and causally. The generalizability of these findings can be limited due to the unnatural conditions in the lab, however. Therefore, intervention studies conducted in a more naturalistic environment can nicely supplement the knowledge gained from lab studies.

1.2.2.2.3 Mindfulness interventions in daily life reduce RNT, reduce symptoms, and improve affect

A few studies integrated a mindfulness intervention into the daily lives of participants via an app and assessed its effects on daily life experiences using ESM. All of these studies compared their mindfulness intervention to a group of participants who completed ESM assessments but no intervention[2].

In one study, adolescents with elevated trait RNT engaged in a mindfulness intervention 2-3 times per day over 3 weeks. Participants completing the mindfulness intervention had stronger day-to-day reductions in daily life RNT (Webb et al., 2022). Although this study assessed RNT before and after each mindfulness induction, the immediate changes associated with each mindfulness intervention as compared to the control group were not reported, unfortunately. Thus, the immediate effects of each mindfulness intervention as compared to the control group remain unknown.

In another study, a community sample completed a mindfulness intervention 10 days before going to sleep. There were no differences in daily life RNT, depression, and anxiety between the groups (Sommerhoff et al., 2023). This suggests that brief, once-

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2 Note, however, that the control group of Zainal & Newman (2023) did not simply complete ESM assessments but was told to monitor their experiences and that this monitoring would be beneficial. Thus, their control condition can be considered more active than solely completing ESM measures.

daily mindfulness interventions may not be impactfully enough to change daily life experiences overall.

Finally, GAD participants engaged in a mindfulness intervention five times per day for 14 days. This study analyzed the immediate effects of each momentary mindfulness intervention showing that it reduced depression and anxiety (Zainal & Newman, 2023). Unfortunately, this study did not assess the immediate effects on RNT.

In sum, there is initial evidence that mindfulness interventions that are delivered more than once per day in daily life can lead to less daily life RNT and symptoms.

Overall, evidence suggests that mindfulness is promising to reduce RNT, reduce symptoms of psychopathology, and improve affect. RCTs reveal that mindfulness treatment programs that typically include several mindfulness interventions lead to improvements in post-treatment measures. However, the immediate effects of each specific mindfulness intervention remain unclear here. Experimental lab studies show that brief mindfulness interventions cause immediate improvements in experiences, yet the generalizability of these findings may be limited due to the artificial conditions in the lab. Studies delivering mindfulness interventions in daily life contexts provide initial evidence that such brief interventions improve everyday experiences. However, only one of these studies reported the immediate impact of their mindfulness intervention, namely on depression and anxiety (Zainal & Newman, 2023). Synthesizing the evidence from the reported mindfulness studies reveals a gap in understanding the impact of brief mindfulness interventions on immediate daily life experiences, particularly in relation to immediate RNT. In other words, it remains unclear whether brief mindfulness interventions in daily life lead to immediate benefits for RNT and affect. Addressing these unanswered questions is the aim of this dissertation.

1.3 AIMS AND RESEARCH QUESTIONS

The goal of this dissertation is to reveal the immediate impact of brief mindfulness interventions on experiences in daily life. Specifically, this dissertation aims to answer the following question: Do brief mindfulness interventions that aim at increasing momentary mindfulness lead to immediate benefits for RNT and affect in daily life?

Two RCTs were conducted to answer this question. In both studies, participants engaged in brief mindfulness interventions several times a day over multiple days in their daily lives and reported their RNT and affect immediately after each intervention. The interventions consisted of audio tracks in which participants were guided through a mindfulness practice that was intended to increase momentary mindfulness. The focus of each study was as follows:

STUDY 1 used a mindfulness intervention originating from mindfulness-based intervention programs. It investigated the effects of its mindfulness intervention on rumination, negative affect, and their dynamic relationship (i.e., the spiral of negativity) in non-clinical participants. This study used a micro-randomized trial design in which each participant engages in *both* the mindfulness intervention and the active control task. This allows for within-person comparisons because each person can serve as their own control. The control task consisted of listening to an unguided audio track. STUDY 1 aimed to answer whether the mindfulness intervention leads to less rumination, less negative affect, and weakens the spiral of negativity between rumination and negative affect as compared to the active control task. Data were collected as part of the study *Momentary Mindfulness and Everyday Emotions* that was conducted at the Functions of Emotions in Everyday Life (FEEL) lab at the University of Melbourne. I had the opportunity to work with this data as part of my research stay at the FEEL lab.

STUDY 2 used a detached mindfulness intervention originating from metacognitive therapy. It investigated the effects of its detached mindfulness intervention on RNT, negative affect, and positive affect in participants with elevated trait RNT. This study consisted of two phases: A baseline phase where participants only completed ESM assessments. And an intervention phase, where participants either engaged in detached mindfulness or an active control task depending on which group they were randomized to. This study design allows us to compare the mindfulness intervention to two control conditions: the baseline phase and the active control task. The control task consisted of an audio track in which participants were guided through a control exercise, which corresponded to a guided imagery exercise. STUDY 2 aimed to answer whether the intervention phase is associated with stronger decreases in RNT, stronger decreases in negative affect, and stronger increases in positive affect and whether these changes are stronger for the detached mindfulness compared to the active control group. Data were collected as part of the study *Sticky Thoughts* that I developed and conducted together with my supervisors at Freie Universität Berlin.

Getting stuck in circles of negative thinking can have detrimental effects on mental health, and such RNT even serves as a risk factor for psychopathology. The findings of this dissertation can broaden our understanding of whether approaching experiences mindfully in our everyday lives can help to disentangle from detrimental cognitive and emotional patterns. Eventually, this knowledge can help to tailor precise and effective interventions for RNT. RNT is a common symptom and is prevalent across disorders. Therefore, finding effective strategies to reduce RNT can meaningfully serve to improve mental health and ideally prevent psychopathology.

CHAPTER 2:

IMPACT OF A MOMENTARY MINDFULNESS INTERVENTION ON RUMINATION, NEGATIVE AFFECT, AND THEIR DYNAMICS IN DAILY LIFE

STUDY 1

The following manuscript was submitted at *Affective Science*:

Bolzenkötter, T., Neubauer, A., B., Koval, P. (2024). Impact of a Momentary Mindfulness Intervention on Rumination, Negative Affect, and their Dynamics in Daily Life. [Manuscript submitted for publication].

Note that the formatting was adjusted to be consistent throughout the dissertation.

Pre-registration: This study was pre-registered at https://osf.io/cdaxb. Prior to conducting the data analyses reported here, the specific research questions and analysis plan was pre-registered at https://osf.io/jz6bm.

Data, Materials and Code availability: Data, analysis code, and research materials are publicly available at https://osf.io/y3gnt/ (see folder "Momentary Mindfulness and Rumination").

2.1 ABSTRACT

Rumination and negative affect are mutually reinforcing experiences. Their dynamic relation can confer vulnerability to psychopathology. Cultivating mindfulness has been proposed as an antidote to such downward spirals of negativity. However, it remains unclear whether practicing mindfulness in daily life causally impacts rumination, negative affect, and their dynamics. We investigated this using a micro-randomized intensive longitudinal trial. Participants (N = 91) were prompted eight times per day for 10 days using a smartphone app. At each prompt, participants were randomized to complete a brief mindfulness intervention or an active-control task and then reported levels of rumination and negative affect. Results of dynamic structural equation models showed that the mindfulness intervention led to lower levels of rumination and negative affect but that it had no reliable impact on their dynamics. Thus, cultivating mindfulness in daily life may be a promising approach for decreasing rumination and negative affect but not their dynamical relation.

Keywords: Mindfulness; rumination; negative affect; micro-randomized trial; ambulatory assessment

2.2 INTRODUCTION

Rumination is a common form of repetitive negative thinking involving persistent distressing thoughts (Martin & Tesser, 2006; Nolen-Hoeksema et al., 2008). Not only is rumination unpleasant, it is theorized to serve as a transdiagnostic risk factor for mental disorders such as depression (Ehring & Watkins, 2008; Kircanski et al., 2015; McEvoy et al., 2013).

One key mechanism through which rumination may confer vulnerability to psychopathology is via its dynamical association with negative affect (NA). That is, rumination increases unpleasant feelings (e.g., sadness, anxiety, anger) which, in turn, predict more ruminative thinking (e.g., Blanke et al., 2022; Moberly & Watkins, 2008), leading to a mutually reinforcing cycle (Garland et al., 2010; Selby et al., 2016). From a dynamical systems perspective, stronger reciprocal associations among rumination and NA may amplify the impact of stressors, such that even relatively mild events can have considerable and persistent psychological effects, potentially hastening an individual's transition into psychopathology (e.g., Wichers et al., 2015). Consistent with this, Stefanovic et al. (2021) found that individuals who showed a stronger association between rumination and NA in daily life were at higher risk of developing depressive symptoms over the following three months. Moreover, rumination and NA each have their own temporal persistence, or inertia, independent of their reciprocal associations (Bean et al., 2020; Blanke et al., 2022). Higher inertia of rumination (Bean et al., 2020, 2021) and NA (Houben et al., 2015) have also both been linked with psychopathology. Thus, the mutually and self-reinforcing dynamics of rumination and NA may have important mental health implications, making them an important target for interventions.

Mindfulness-based interventions, which typically involve the cultivation of purposeful, curious, non-judgmental, or non-reactive momentary awareness (Kabat-Zinn & Hanh, 2009; Van Dam et al., 2018), are promising candidates for interrupting the reinforcing dynamics among rumination and NA. Evidence that mindfulness may reduce rumination, NA, and their reciprocal association, has been observed both in the lab and in daily life. For example, a meta-analysis of lab experiments showed that inducing state mindfulness reliably reduced rumination and NA (Leyland et al., 2019). Well-controlled lab experiments permit strong causal inferences about the effects of mindfulness on cognitive and affective processes. However, experiments often lack ecological validity, making it unclear whether effects observed in the lab generalize to daily life.

Ambulatory assessment, including the experience sampling method (ESM), allows researchers to investigate how mindfulness influences spontaneous thoughts and feelings in daily life. Previous ESM studies have found that mindfulness was associated with lower levels of rumination and NA, either by measuring natural fluctuations in state mindfulness (Blanke et al., 2018, 2020; Brown & Ryan, 2003), or randomizing individuals to a mindfulness versus control intervention (Bolzenkötter et al., 2023; Rowland et al., 2020).[3] Moreover, a few studies suggest that mindfulness might also moderate the temporal dynamics of these experiences. For example, Blanke et al. (2020) reported that the within-person association between rumination and NA was attenuated at times when people reported higher levels of mindfulness in daily life. Other studies have also linked trait mindfulness with lower inertia of NA (Keng & Tong, 2016; Rowland et al., 2020). In sum, a handful of ESM studies have demonstrated that mindfulness may influence levels and temporal dynamics of rumination and NA in daily life.

However, there is still a dearth of studies experimentally manipulating mindfulness and assessing its effects on immediate experiences and their dynamics in daily life. It thus remains unclear whether cultivating mindful states could lead to less

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[3] Bolzenkötter et al.'s (2023) findings suggest these effects may not be specific to mindfulness, given that they observed similar reductions in rumination and NA among participants randomized to a guided imagery (active-control) group.

unpleasant thoughts and feelings in the moment and/or interrupt their mutually and self-reinforcing dynamics. Importantly, no previous studies have investigated the within-person causal effects of mindfulness on rumination and NA in daily life. This would require experimentally manipulating mindfulness within (rather than between) individuals.

The present study. We aimed to fill this gap by investigating the within-person causal effects of a brief momentary mindfulness intervention on rumination, NA, and their dynamics in daily life. We analyzed data from the Momentary Mindfulness and Everyday Emotion (MMEE) study, in which participants were randomized to complete either a mindfulness intervention or an active-control task eight times per day for 10 days, using a smartphone app. Unlike a traditional RCT, where participants are randomized to an intervention or control group, the MMEE study adopted a micro-randomized design, in which each participant received both intervention and control at different occasions (Klasnja et al., 2015; Qian et al., 2022). In such designs, each person serves as their own control, allowing us to estimate within-person causal effects of mindfulness on psychological experience. Immediately after completing the mindfulness intervention or active-control task, participants reported their levels of rumination and NA. Drawing on the literature reviewed above, we hypothesized that, relative to the active-control task, completing the mindfulness intervention would lead to (i) lower levels of rumination (H1) and NA (H2); (ii) weaker within-person effects of rumination on NA (H3) and NA on rumination (H4); and (iii) weaker temporal persistence (i.e., inertia) of rumination (H5) and NA (H6).

2.3 METHOD

The MMEE study was approved by the University of Melbourne Human Research Ethics Committee (No. HREC No. 2056669.2). Participants completed the study in five batches (approximately 20-30 people per batch) between June 11th and August 22nd 2020.

All participants gave informed consent and were reimbursed up to £75.50, with reimbursement partly tied to ESM compliance (for details, see https://osf.io/cdaxb).

2.3.1 PARTICIPANTS

Our final sample comprised 91 Australian residents, whose mean age was 29.2 years (*SD* = 8.99) and of whom 51.6% were female (46.2% male, 2.2% other). Our sample can be considered a convenience sample: participants were recruited via the online research platform Prolific (www.prolific.co) and enrolled in a study investigating how brief mindfulness training impacts everyday emotions. To be eligible, participants were required to (1) be aged at least 18 years; (2) be fluent in English; (3) have a smartphone running Android or iOS; (4) have normal or corrected-to-normal vision; (5) have no hearing loss/difficulties; and (6) have no untreated mental health conditions impacting their daily functioning. See Supplemental Material for divergence of this inclusion criteria from the original pre-registration as well as for additional demographic characteristics.

After initially recruiting 146 participants, 28 participants did not commence the ESM phase (due to technical reasons or voluntarily withdrawal). Additionally, 21 participants whose compliance with the ESM protocol or the intervention was low were excluded during data collection (for detailed exclusion criteria, see https://osf.io/cdaxb). Finally, after inspecting the data, we excluded six more participants with low intervention compliance who had not been previously excluded during data collection. We report supplemental analyses using all available data, including from these six participants, which support identical conclusions. We retained data from two additional participants with low ESM compliance who were not excluded during data collection. Flow of participants is included in Figure S1 in the Supplemental Material.

Sample Size and Power. Based on Schultzberg and Muthen's (2018) guidelines for power in DSEM, we originally aimed to recruit a sample of N=150 participants sampled at T=80 occasions to obtain a sufficiently large sample even after participant attrition, exclusions, and missing data. Due to time and funding constraints, we stopped data collection after recruiting 146 participants. After exclusions and attrition (described above), our final sample size comprised N=91 participants each with approximately T=63 complete ESM surveys. Given that this is likely underpowered for detecting between-person and/or cross-level interaction effects (Schultzberg & Muthén, 2018), we decided to focus exclusively on within-person effects in the current report. Schultzberg and Muthen's (2018) findings indicate that within-person parameters can be estimated with low relative bias and good coverage with N and T between 50 and 75, which our final sample fulfills. Finally, we ran a power analysis using Murayama et al.'s (2022) online multilevel power calculator to estimate whether our final sample was sufficient to detect within-person interaction effects of similar magnitude as reported by Blanke et al. (2020). This analysis indicated that a Level-2 sample of N=90 would be sufficient to yield 80% power of detecting a within-person effect equivalent to the smallest significant interaction effect observed by Blanke et al. (2020) (i.e., Study 1: rumination x mindful-attention predicting NA: *Est.* = −0.05, *SE* = 0.02, t = −2.5, Level-2 N = 70). Thus, our final sample size (N=91) was adequately powered to detect within-person effects of similar magnitude as those reported by Blanke et al. (2020).

2.3.2 EXPERIMENTAL DESIGN

This study adopted a novel cross-classified experimental design, whereby the mindfulness intervention was randomized at each occasion (within persons), while the probability of receiving the intervention (vs. active-control task) was randomly assigned between persons *and* between occasions. We adopted this design to allow estimation of within-person, between-person, and between-occasion causal effects. However, as preliminary analyses indicated negligible between-occasion variance in our outcomes (see Supplemental Material), we opted to estimate two-level (rather than cross-classified) models. Moreover, as discussed above, given our final sample comprised N=91 participants, we were likely underpowered to detect between-person effects and thus our analyses focus exclusively on within-person effects. However, our analytic approach (detailed below) accounts for between-person differences by modeling random effects for all within-person parameters. For more detail about the study design and a discussion of statistical approaches for estimating causal effects using this design, please see Neubauer et al. (2023).

2.3.3 MATERIALS AND PROCEDURE

2.3.3.1 Baseline Session

Two days prior to the ESM phase, participants completed an online baseline session, during which they provided informed consent, reported basic demographic information (e.g., age, gender, education, ethnicity), and their previous meditation experience and practice frequency (see Table 1). Additionally, they completed several validated retrospective questionnaires that were not analyzed as part of this study (see https://osf.io/cdaxb).

Table 1

Demographic Information as well as Experience and Current Practice of Meditation

Age in years (*M*, *SD*)		29.2 (8.99)
Gender (*n*, %)		
	female	47 (51.6)
	male	42 (46.2)
	other	2 (2.2)
Ethnicity (*n*, %)		
	Caucasian	60 (65.9)
	Asian	25 (27.5)
	Aboriginal or Torres Strait Islander	0 (0)
	African or African American	1 (1.1)
	Middle Eastern	1 (1.1)
	Hispanic	0 (0)
	other	4 (4.4)
Education (*n*, %)		
	did not complete high school	0 (0)
	high school	19 (20.9)
	trade, technical or vocational training	11 (12.1)
	bachelor degree	43 (47.3)
	postgraduate degree	18 (19.8)
Experience with meditation (*n*, %)		
	I have practiced meditation for a year or longer	2 (2.2)
	I have practiced meditation for 1-12 months	4 (4.4)
	I have practiced meditation for 1-4 weeks	6 (6.6)
	I have tried meditation a few times	56 (61.5)
	I have no previous experience with meditation	23 (25.3)
Practicing meditation (*n*, %)		
	no	70 (76.9)
	yes, occasionally	16 (17.6)
	yes, weekly	3 (3.3)
	yes, daily or more	2 (2.2)

Note. M = mean, *SD* = standard deviation, *n* = number of participants, % = percent of participants.

2.3.3.2 ESM Phase

One day prior to the ESM phase (i.e., day after baseline), participants installed the ESM smartphone app, SEMA3 (O'Brien et al., 2023), and watched videos with detailed instructions about how to use SEMA3, and explaining the content of the ESM survey as well as the mindfulness intervention and active-control tasks. That evening, participants received two practice ESM surveys, which were excluded from analyses.

The ESM phase began the next day. Over the following 10 days, participants received eight ESM surveys per day scheduled between 9:00 a.m. and 8.40 p.m. following a stratified random-interval scheme (approximately one survey every 90 minutes). ESM surveys expired after 40 minutes to ensure no overlap between successive surveys (see https://osf.io/cdaxb for more detail on the ESM protocol).

2.3.3.2.1 Mindfulness intervention and active-control task

At each ESM survey, participants were randomly assigned to complete either a mindfulness intervention or an active-control task, which each involved listening to a short audio track hosted on Soundcloud.com. For the mindfulness intervention (https://soundcloud.com/momentary-mindfulness/task-one), we used a freely available recording of Williams and Penman's (2011) "Three Minute Breathing Space", an audio-guided mindfulness meditation exercise lasting 3 min and 22 s. The exercise invited participants to attend to their thoughts and feelings, and especially to the sensation of their breathing, with openness and curiosity. The active-control task (https://soundcloud.com/momentary-mindfulness/task-two) was an audio clip containing neutral background sound (ambient recordings of public places, such as cafes), which we edited to be approximately equivalent to the mindfulness intervention in terms of duration and audio profile (i.e., volume, number of silences, etc.). We included the active-control task to determine if any observed effects of the mindfulness intervention were simply due to the possible distracting effects of interrupting current thoughts/activities by listening to a short audio clip. After completing either task, participants were asked to return to SEMA3 and complete several ESM items.

2.3.3.2.2 ESM items

ESM surveys included a total of 15 items, all rated on slider scales from 0 (*not at all*) to 100 (*very much*). Below, we describe the eight ESM items relevant to the current study (see https://osf.io/cdaxb for details of other ESM items). The first three ESM items assessed rumination and mindfulness experiences during the intervention (or active-control) task. These items were presented in a random order at each ESM survey.

Rumination. We assessed state rumination using the item "Over the last few minutes, did you find yourself getting stuck on your feelings and problems?" This item is similar to Kircanski et al.'s (2015) measure of state rumination. Our item differs from Kircanski et al.'s in terms of the time-frame ("over the last few minutes") as well as the phrase "getting stuck on", which we included to capture the core ruminative feature of uncontrollability (Rosenkranz et al., 2020).

Mindfulness. We assessed state mindfulness with two items adapted from the Toronto Mindfulness Scale (Lau et al., 2006) designed to capture the core mindfulness components of *curiosity* ("Over the last few minutes, were you curious about each thought/feeling that you had?") and *decentering* ("Over the last few minutes, did you try to accept each thought/feeling you had, whether it was pleasant or unpleasant?"). For our manipulation check (see below), we combined the two mindfulness items into a state mindfulness composite (r_{Within} = .29; r_{Between} = .71).

Negative affect. After completing the above rumination and mindfulness items, participants rated their momentary positive and negative feelings in response to the item "Right now, how [*adjective*] do you feel?" including five adjectives selected to capture high- and low-activation NA, as conceptualized in affective circumplex models (Yik et al., 2011): "sad", "stressed", "anxious", "angry", and "depressed". We averaged each participant's responses to the five negative items at each ESM survey to form an NA scale (ω_{Within} = 0.79; ω_{Between} = 0.94).

2.3.4 DATA PREPARATION

We prepared data using R version 4.0.5 (R Core Team, 2021). A technical error occurred on Day 1 of the ESM phase for the first batch of participants making these data unusable; we therefore removed these surveys prior to running analyses. Additionally, we considered ESM items completed in less than 750ms as potentially reflecting careless responding (McCabe et al., 2012) and replaced these with missing values. This affected 113 (0.19%) of the 57,432 completed ESM items.

2.3.5 DATA ANALYSES

We analyzed data using dynamic structural equation modeling (DSEM; Asparouhov et al., 2018) implemented in Mplus 8.9 (Muthén & Muthén, 1998–2017). DSEM combines structural equation modeling with multilevel time-series modeling, making it ideally suited for analysis of intensive longitudinal data (Hamaker et al., 2023). DSEM has several benefits over standard multilevel regression as illustrated by McNeish & Hamaker (2020).

DSEM uses latent centering to decompose observed variables into between- and within-person components. The between-person component represents trait-like mean levels of observed variables, whereas the within-person component represents dynamic deviations of observed variables around their stable mean levels. The latter were of primary interest to us as our hypotheses concerned within-person dynamic effects. Consequently, we describe only the within-person parts of our DSEM models in detail below. We include full model diagrams depicting latent variable decomposition and within-, and between-person models in the Supplemental Material (see Figures S2-S10).

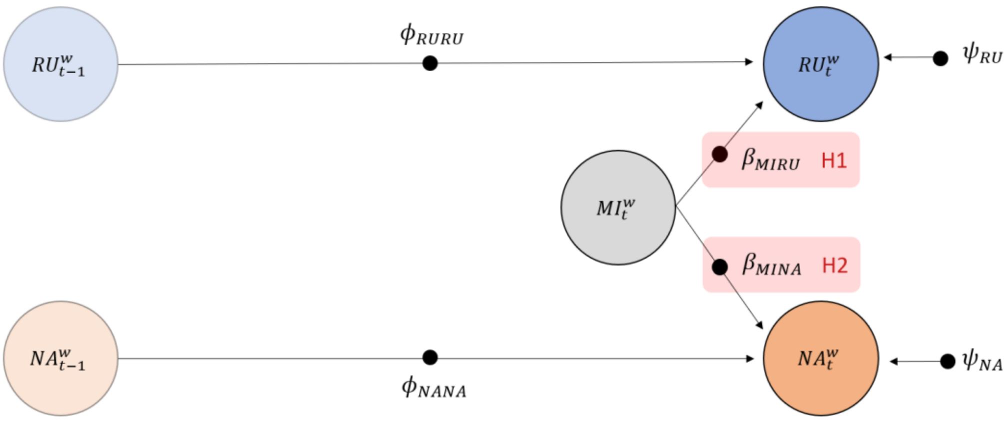
We ran two-level models to account for ESM surveys as nested within persons. All within-person parameters were modeled as random effects that could vary between persons. At the between-person level, all random effects were allowed to freely correlate (i.e., we estimated an unstructured covariance matrix). We used Bayesian estimation with Mplus's default uninformative priors and we checked model convergence using posterior scale reduction (PSR) values < 1.05 after 5000 iterations with a thinning factor of 10. When a model did not converge, we re-ran the model with double the iterations and again checked convergence. When a model converged, we also re-ran the model with double the iterations to check that convergence was stable. We report the results of all final models (i.e., with double the number of iterations required to achieve convergence). We considered effects as meaningfully different from zero (i.e., "significant") when their 95% credible interval did not include zero. We estimated three models to test our hypotheses. Following Hamaker et al. (2023), we label (cross)-regressive effects of one variable predicting another as Beta (β), auto-regressive effects of a variable predicting itself as Phi (ϕ), and residual variances as Psi (ψ). All models were pre-registered prior to conducting analyses (see https://osf.io/jz6bm).

2.3.5.1 Model 1: Effect of the Mindfulness Intervention on Rumination and NA Levels

Model 1 tested the hypotheses that the mindfulness intervention would predict lower levels of rumination (H1) and NA (H2) relative to the active-control task. As shown in Figure 2, rumination (RU_t^w) and NA (NA_t^w) at occasion *t* were regressed onto a binary mindfulness intervention variable (MI_t^w; where 1 = mindfulness intervention and 0 = control task delivered at occasion *t*). The slopes β_{MIRU} and β_{MINA} represent causal effects of the mindfulness intervention on rumination and NA and therefore tested H1 and H2, respectively (see red shaded parameters in Figure 2). We also controlled for the autoregressive effects of rumination (ϕ_{RURU}) and NA (ϕ_{NANA}) by predicting levels of rumination and NA at occasion *t* by their respective levels at the previous occasion *t*-1. Lastly, Model 1 included random residual variances for rumination (ψ_{RU}) and NA (ψ_{NA}) reflecting unexplained variance in each outcome after accounting for all predictors.

Figure 2

Within-Person Model Investigating the Effect of the Mindfulness Intervention on Levels of Rumination and NA



Note. The filled circles indicate that the parameters are random. RU = rumination, NA = negative affect, MI = mindfulness intervention, *w* = within-person component of DSEM model, ϕ_{RURU} = autoregressive effect of rumination, ϕ_{NANA}= autoregressive effect of NA, β_{MIRU} = effect of mindfulness intervention at *t* on rumination at *t*, β_{MINA} = effect of mindfulness intervention at *t* on NA at *t*, ψ_{RU}= residual variance of rumination, ψ_{NA}= residual variance of NA. H1 = hypothesis 1, H2 = hypothesis 2.

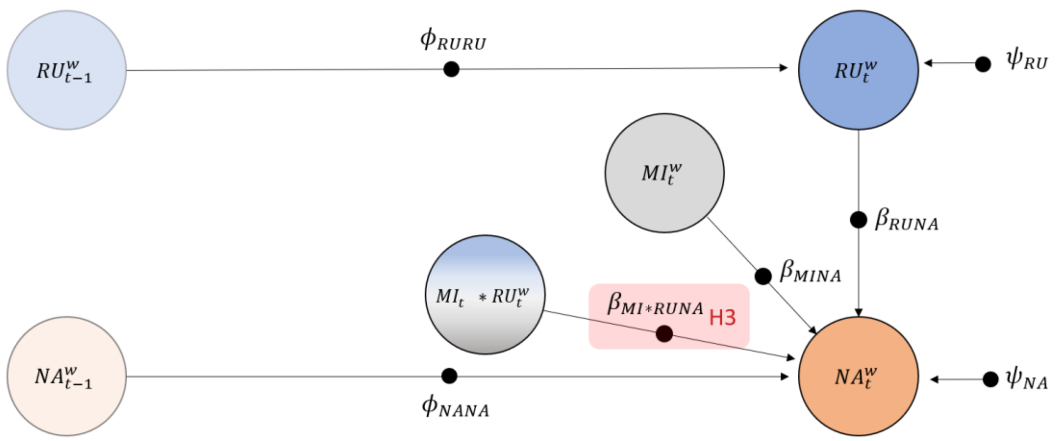
2.3.5.2 Model 2: Effect of the Mindfulness Intervention on the Cross-Regressive Effect of Rumination on NA

Model 2 tested the hypothesis that the mindfulness intervention would predict a weaker cross-regressive effect of rumination on NA relative to the active control task (H3). As shown in Figure 3, NA (NA^w_t) at occasion *t* was regressed onto rumination at occasion t (RU^w_t), the mindfulness intervention at occasion *t* (MI^w_t), and their product ($MI_t * RU^w_t$) representing the interaction between the mindfulness intervention and rumination. The slope $\beta_{MI*RUNA}$ represents the causal effect of the mindfulness intervention on the cross-regressive effect of rumination on NA and therefore tested H3 (see red shaded parameter in Figure 3). Note that although NA is predicted by rumination measured at the same occasion (*t*), we consider rumination to be *conceptually lagged* because participants reported their rumination “over the last few minutes”. In contrast, participants reported their NA “right now” at each occasion *t*. Therefore, following Hamaker et al. (2023), we modelled how rumination predicted NA using a so-called *lag-*

0 cross-regressive effect, rather than a *lag*-1 effect. A recent simulation study suggests that this approach is a valid way of modelling causal effects among conceptually lagged and momentary variables (Luo & Hu, 2023). As in the previous model, we included autoregressive effects and residual variances for rumination and NA.

Figure 3

Within-Person Model Investigating the Effect of the Mindfulness Intervention on the Cross-Regressive Effect of Rumination on NA



Note. The filled circles indicate that the parameters are random. RU = rumination, NA = negative affect, MI = mindfulness intervention, *w* = within-person component of DSEM model, ϕ_{RURU} = autoregressive effect of rumination, ϕ_{NANA}= autoregressive effect of NA, β_{RUNA} = cross-regressive effect of rumination at *t* on NA at *t*, β_{MINA} = effect of mindfulness intervention at *t* on NA at *t*, $\beta_{MI*RUNA}$= effect of the mindfulness intervention at *t* on the cross-regressive effect of rumination at *t* on NA at *t*, ψ_{RU}= residual variance of rumination, ψ_{NA}= residual variance of NA.

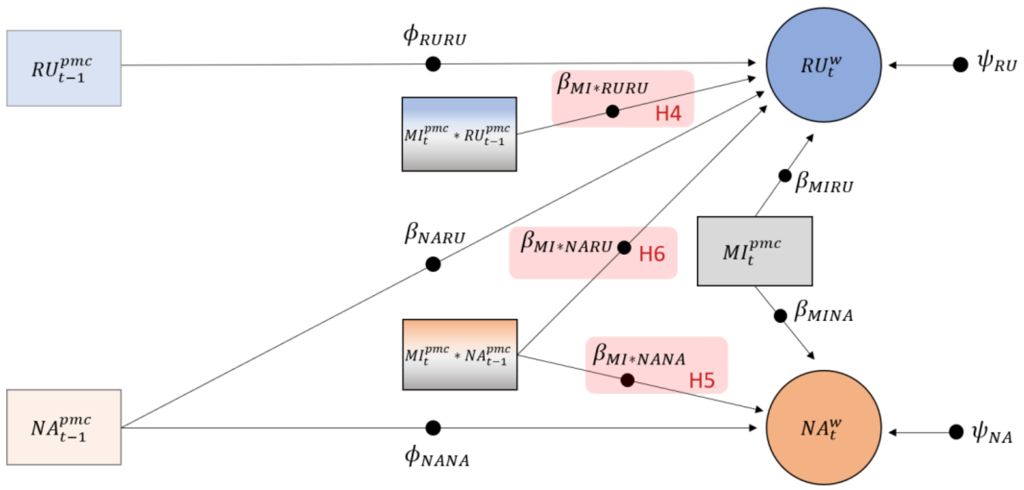
2.3.5.3 Model 3: Effect of the Mindfulness Intervention on the Cross-Regressive Effect of NA on Rumination and on the Autoregressive Effects of Rumination and NA

Model 3 tested the hypothesis that, relative to the active-control task, the mindfulness intervention would weaken the cross-regressive effect of NA on rumination (H4), as well as the temporal persistence of rumination (H5) and NA (H6). As shown in Figure 4, we regressed rumination at occasion *t* (RU_t^{pmc}) onto NA at the *previous* occasion *t*-1 (NA_{t-1}^{pmc}), the mindfulness intervention at occasion *t* (MI_t^{pmc}) and their product ($MI_t * NA_{t-1}^{pmc}$). The slope $\beta_{MI*NARU}$ represents the effect of the mindfulness intervention on the cross-regressive effect of NA on rumination and therefore tested H4 (see red shaded parameter in Figure 4).

As in the previous models, we included autoregressive effects and residual variances for rumination and NA. Finally, to test hypotheses H5 and H6, we included interactions between the mindfulness intervention at occasion t and lagged rumination ($MI_t^{pmc} * RU_{t-1}^{pmc}$) and NA ($MI_t^{pmc} * NA_{t-1}^{pmc}$). Thus, the slopes $\beta_{MI*RURU}$ and $\beta_{MI*NANA}$ represent effects of the mindfulness intervention on the autoregressive effects of rumination and NA (testing H5 and H6, respectively; see red shaded parameters in Figure 4). Because latent centering is currently not possible when modelling within level interactions that include lagged variables, we entered observed mean-centered predictors in Model 3, represented as rectangles in Figure 4 (see Supplemental Material for more details).

Figure 4

Within-Person Model Investigating the Effect of the Mindfulness Intervention on the Cross-Regressive Effect of NA on Rumination and the Autoregressive Effects of Rumination and NA



Note. The filled circles indicate that the parameters are random. RU = rumination, NA = negative affect, MI = mindfulness intervention, w = within-person component of DSEM model, pmc = observed person-mean centered, ϕ_{RURU} = autoregressive effect of rumination, ϕ_{NANA} = autoregressive effect of NA, ϕ_{NARU} = cross-regressive effect of NA at t-1 on rumination at t, β_{MIRU} = effect of mindfulness intervention at t on rumination at t, β_{MINA}= effect of mindfulness intervention at t on NA at t, $\beta_{MI*NARU}$= effect of the mindfulness intervention on the cross-regressive effect of NA at t-1 on rumination at t, $\beta_{MI*RURU}$ = effect of the mindfulness intervention at t on the autoregressive effect of rumination, $\beta_{MI*NANA}$ = effect of the mindfulness intervention at t on the autoregressive effect of NA, ψ_{RU}= residual variance of rumination, ψ_{NA}= residual variance of NA.

2.4 RESULTS

For all analyses, we report unstandardized fixed effects (medians of the posterior distribution for each parameter) and their 95% credible intervals. For our main analyses we also report within-person standardized parameter estimates in Tables S2-S4 in the Supplemental Material.

2.4.1 PRELIMINARY ANALYSES

2.4.1.1 Descriptive Statistics

Participants answered an average of 79.2% (*SD* = 13.5, range = 33.3-98.8) of all delivered ESM surveys, yielding a total of 5,691 completed ESM surveys. On average, participants were randomized to complete the mindfulness intervention (vs. active-control task) on

49.8% (SD = 15, range = 17.6-87.2) of all completed ESM surveys. Participants spent the required three minutes listening to the audio tasks on 90.7% (SD = 9.67, range = 62.0-100) of completed surveys, on average. We checked this compliance with the audio tasks by inspecting the reaction time to the item during which participants were supposed to complete the audio task. Preliminary null models indicated that, on average, participants reported moderate levels of rumination and state mindfulness, but relatively low levels of NA across the ESM phase (see Table 2). All ESM measures showed substantial variation within and between persons, with ICCs between .48 and .67.

Table 2

Descriptive Statistics for ESM Measures

	M	SD_W	SD_B	ICC
Rumination	36.06 [32.55, 39.95]	18.59 [18.26, 18.93]	17.89 [15.21, 20.67]	0.48 [0.41, 0.56]
Negative Affect	17.04 [14.22, 20.32]	10.34 [10.18, 10.53]	14.69 [12.49, 16.94]	0.67 [0.60, 0.73]
State mindfulness	52.02 [48.58, 55.77]	13.35 [13.11, 13,60]	17.39 [14.97, 20.19]	0.63 [0.56, 0.70]

Note. Descriptive statistics are based on null models estimated in Mplus. M = mean; SD_W = within-person standard deviation; SD_B = between-person standard deviation; ICC = intraclass correlation, which represents the ratio of between-person to total variation for each measure. Values in square brackets are 95% Bayesian credibility intervals.

2.4.1.2 Manipulation Check

We tested whether the mindfulness intervention induced higher levels of state mindfulness by regressing state mindfulness at each occasion t onto the mindfulness intervention variable at each occasion t (see Supplemental Material for detailed model and results). This analysis indicated that the mindfulness intervention was successful in inducing increases in state mindfulness: On average, participants reported significantly higher mindfulness after completing the mindfulness intervention versus the active-control task (b = 3.38, 95% CI = [2.39, 4.36]).

2.4.2 MAIN ANALYSES

2.4.2.1 Model 1

Results of Model 1 (see Table 3) showed that the average effect of the mindfulness intervention on rumination was significantly negative (see β_{MIRU} slope). Thus, consistent with H1, participants reported levels of rumination that were approximately 2.7 points lower (on a 0-100 scale) after completing the mindfulness intervention as compared with the active-control task. Similarly, consistent with H2, the effect of the mindfulness intervention on NA was significantly negative (see β_{MINA} slope), implying that participants reported levels of NA that were approximately 1.2 points lower after completing the mindfulness intervention as compared with the active-control task.

Table 3

Unstandardized Fixed Effects (median) from Model 1

	Estimate	*95% CI*	
Parameters		*Lower*	*Upper*
RU intercept	36.016	32.308	39.777
NA intercept	15.875	13.481	18.201
Autoregressive effects			
ϕ_{RURU}	0.204	0.152	0.256
ϕ_{NANA}	0.375	0.317	0.432
Effects of mindfulness intervention			
β_{MIRU}	-2.713	-3.986	-1.455
β_{MINA}	-1.203	-1.725	-0.696
Log residual variances			
ψ_{RU}	5.407	5.243	5.568
ψ_{NA}	3.886	3.653	4.112

Note. CI = credible interval; RU = rumination; NA = negative affect; MI = mindfulness intervention; ϕ_{RURU}= autoregressive effect of rumination; ϕ_{NANA} = autoregressive effect of NA; β_{MIRU} = effect of mindfulness intervention at *t* on rumination at *t*; β_{MINA}= effect of mindfulness intervention at *t* on NA at *t*; ψ_{RU}= log transformed residual variance of rumination; ψ_{NA}= log transformed residual variance of NA.

2.4.2.2 Model 2

Results from Model 2 (see Table 4) showed that the mindfulness intervention did not significantly moderate the cross-regressive effect of rumination on NA (see $\beta_{MI*RUNA}$ slope). Thus, contrary to H3, the mindfulness intervention did not weaken the effect of rumination on NA. In fact, contrary to our hypothesis, the standardized estimate of $\beta_{MI*RUNA}$ was significant and positive (*Est.* = 0.082, 95% *CI* = [0.026, 0.143]), suggesting that the mindfulness intervention may have strengthened the effect of rumination on NA (see Table S3 in the Supplemental Material for full standardized model results). As we discuss further below, we urge caution in interpreting this effect given the discrepancy between its raw and standardized estimates.

Table 4

Unstandardized Fixed Effects (median) from Model 2

	Estimate	*95% CI*	
Parameters		*Lower*	*Upper*
RU intercept	35.962	32.318	39.545
NA intercept	15.971	13.526	18.327
Autoregressive effects			
ϕ_{RURU}	0.206	0.151	0.260
ϕ_{NANA}	0.317	0.259	0.374
Cross-regressive effects			
β_{RUNA}	0.159	0.117	0.201
(Interaction) Effects of mindfulness intervention			
β_{MINA}	-1.200	-1.834	-0.588
$\beta_{MI*RUNA}$	0.027	-0.011	0.065
Log residual variances			
ψ_{RU}	5.559	5.405	5.710
ψ_{NA}	3.738	3.511	3.970

Note. CI = credible interval; RU = rumination; NA = negative affect; MI = mindfulness intervention; ϕ_{RURU}= autoregressive effect of rumination; ϕ_{NANA} = autoregressive effect of NA; β_{RUNA}= cross-regressive effect of rumination at *t* on NA at *t*; β_{MINA} = effect of mindfulness intervention at *t* on NA at *t*; $\beta_{MI*RUNA}$= effect of the mindfulness intervention at *t* on the cross-regressive effect of rumination at *t* on NA at *t*; ψ_{RU}= log transformed residual variance of rumination; ψ_{NA}= log transformed residual variance of NA.

2.4.2.3 Model 3

Results of Model 3 (see Table 5) showed that the mindfulness intervention did not significantly moderate the cross-regressive effect of NA on rumination (see $\beta_{MI*NARU}$ slope). Thus, contrary to H4, previous NA was not less strongly associated with rumination when the mindfulness intervention was completed as compared to the active-control task. Similarly, the mindfulness intervention did not significantly moderate the autoregressive effects of rumination or NA (see $\beta_{MI*RURU}$ and $\beta_{MI*NANA}$ slopes, respectively). Thus, contrary to H5 and H6, rumination and NA were not less persistent when the mindfulness intervention was completed as compared to the active-control task.

Table 5

Unstandardized Fixed Effects (median) from Model 3

Parameters	*Estimate*	*95% CI*	
		Lower	*Upper*
RU intercept	36.009	31.704	40.503
NA intercept	17.003	13.462	20.557
Autoregressive effects			
ϕ_{RURU}	0.156	0.100	0.210
ϕ_{NANA}	0.338	0.276	0.397
Cross-regressive effects			
ϕ_{NARU}	0.159	0.117	0.201
(Interaction) Effects of mindfulness intervention			
β_{MIRU}	-4.181	-6.713	-1.713
β_{MINA}	-1.518	-2.491	-0.629
$\beta_{MI*NARU}$	0.041	-0.142	0.230
$\beta_{MI*RURU}$	0.014	-0.085	0.114
$\beta_{MI*NANA}$	0.010	-0.081	0.103
Log residual variances			
ψ_{RU}	5.451	5.255	5.638
ψ_{NA}	3.942	3.660	4.205

Note. CI = credible interval; RU = rumination; NA = negative affect; MI = mindfulness intervention; ϕ_{RURU}= autoregressive effect of rumination; ϕ_{NANA} = autoregressive effect of NA; ϕ_{NARU} = cross-regressive effect of NA at t-1 on rumination at t; β_{MIRU}= effect of mindfulness intervention at t on rumination at t; β_{MINA}= effect of mindfulness intervention at t on NA at t; $\beta_{MI*NARU}$ = effect of the mindfulness intervention at t on the cross-regressive effect of NA at t-1on rumination at t; $\beta_{MI*RURU}$ $\beta_{MI*RURU}$ = effect of the mindfulness intervention at t on the autoregressive effect of rumination; $\beta_{MI*NANA}$ = effect of the mindfulness intervention at t on the autoregressive effect of NA; ψ_{RU}= log transformed residual variance of rumination, ψ_{NA}= log transformed residual variance of NA.

2.4.3 SUPPLEMENTAL ANALYSES

We ran a series of additional analyses designed to test the robustness of our main findings, by (1) varying our approach of dealing with intervention non-compliance, (2) varying our approach of dealing with unequal time intervals, and (3) including random residual covariances among outcome variables. Models with these alternative specifications resulted in very similar findings supporting the same conclusions as our main analyses. Further details and model results from these additional analyses are provided in the Supplemental Material (see Table S5-S7).

2.5 DISCUSSION

Mindfulness interventions are often promoted as helpful in alleviating psychological distress and interrupting mutually and self-reinforcing dynamic associations among negative thoughts and feelings. However, previous studies were not able to test the within-person causal effect of engaging in brief mindfulness exercises in daily life on rumination, NA, and their dynamics. We investigated this possibility using a micro-randomized trial, in which participants received a mindfulness intervention and an active-control task at random moments in their daily lives and then reported their experiences of rumination and NA.

Results of our first model revealed that the mindfulness intervention predicted lower levels of rumination and NA, consistent with our hypotheses and with results of previous observational ESM studies (Blanke et al., 2018, 2020; Brown & Ryan, 2003). Due to random assignment of the mindfulness intervention (vs. active-control task) at each occasion, our findings extend upon previous research by providing the first evidence of a within-person causal effect of mindfulness on rumination and NA in daily life. Previous studies have combined experimental designs with ESM to study the causal impact of mindfulness on daily life psychological experience (e.g., Bolzenkötter et al., 2023; Rowland et al., 2020). However, these studies randomized individuals, not measurement occasions, to a mindfulness (vs. control) intervention. Results of previous ESM studies therefore represent between-person effects of mindfulness, which cannot necessarily be generalized to the within-person level (Molenaar, 2004; Neubauer et al., 2023).

However, contrary to our hypotheses, we found no consistent evidence that the mindfulness intervention influenced the temporal dynamics of rumination and NA.

Specifically, results of our second model were inconsistent with our prediction that mindfulness would weaken the cross-regressive effect of rumination on NA. This also diverges from the results of Blanke et al.'s (2020) observational ESM study. In fact, standardized estimates from our second model suggest that the mindfulness intervention may have strengthened the cross-regressive effect of rumination on NA. To understand this unexpected finding, consider that the standardized results are based on within-person standardized variables, which explicitly remove between-person differences in means and variances. This suggests that between-person differences in variability of rumination and/or NA may have reduced the reliability of the unstandardized interaction effect, which was also positive but had a 95% CI that crossed zero (compare Rowland et al., 2020 for a similar divergent finding between standardized and non-standardized results). In sum, although we urge caution in interpreting the positive standardized interaction effect, we can be relatively confident that our results do not support the prediction that inducing mindfulness weakens the effect of rumination on NA.

Finally, results of our third model were inconsistent with our hypotheses that the mindfulness intervention would weaken the effect of NA on subsequent rumination, as well as the inertia of rumination and NA. Note, however, that unlike the first two models, here we estimated lagged effects across successive ESM surveys. Thus, our findings suggest that the mindfulness intervention did not impact how much previous experiences of NA predicted themselves or rumination across a time interval of roughly 90 minutes. This may be explained by the relatively long timespan between consecutive measurement occasions surveys combined with the brevity of the mindfulness intervention. We note, however, that our findings are consistent with Rowland et al. (2020), who found no within-person moderating effect of momentary mindfulness on NA inertia.

2.5.1 LIMITATIONS AND FUTURE DIRECTIONS

Our study has limitations that may be addressed by future research. First, participants completed both the mindfulness intervention and control tasks in our study. This may have induced a demand effect whereby participants expected the mindfulness intervention to be more effective. This is less of an issue in between-person experimental designs, where participants are randomized to either a treatment or control condition. Future studies using within-person designs could mitigate this concern by attempting to equalize participants' expectations about the effectiveness of the mindfulness and control interventions.

Second, we compared a brief mindfulness intervention with a control task comprising neutral background noise. Thus, our findings might not generalize to other forms of mindfulness practice or to other control tasks. For example, Bolzenkötter et al. (2023) found that a guided imagery control task and a mindfulness intervention had comparable effects on rumination and NA in daily life, challenging the specificity of mindfulness per se as the underlying mechanism. Although we interpret the current findings as consistent with a causal effect of mindfulness on rumination and NA, we cannot be sure which ingredient(s) of mindfulness interventions are implicated in their salutary effects.

Finally, future studies may also explore the effects of a longer mindfulness intervention or use a denser ESM design with shorter time intervals between measurement occasions. Such designs could reveal more fleeting effects of mindfulness on the dynamics of psychological experience, which did not emerge in the current study.

2.5.2 CONCLUSION

This is the first study to experimentally manipulate participants' state mindfulness in daily life and investigate the within-person impact on levels and temporal dynamics of rumination and NA. Our results suggest that inducing state mindfulness via a brief exercise leads to less rumination and NA in the immediate short-term. Increasing peoples' mindfulness in daily life may therefore have short-term benefits for mental well-being. Our results further suggest that moments of higher state mindfulness do not reliably lead to weaker mutually and self-reinforcing dynamics among rumination and NA. Thus, brief mindfulness practices appear insufficient to disrupt the dynamical relations between rumination and NA.

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2.7 DECLARATIONS

Conflicts of Interest: We have no conflict of interest to disclose.

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Ethical Approval: The study was approved by the University of Melbourne Human Research Ethics Committee (No. HREC No. 2056669.2).

Consent to Participate: Informed consent was obtained from all individual participants included in the study.

Transparency and Data/Code Availability: This study was pre-registered at https://osf.io/cdaxb. Prior to conducting the data analyses reported here, we pre-registered our specific research questions and analysis plan at https://osf.io/jz6bm. We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study. All data, analysis code, and research materials are publicly available at https://osf.io/y3gnt/ (see folder "Momentary Mindfulness and Rumination"). We prepared the data with R version 4.0.5 (R Core Team, 2021) and analyzed them with Mplus version 8.9 (Muthén & Muthén, 1998–2017).

Author's Contributions: TB: Methodology, Formal Analysis, Writing – Original Draft, Writing – Review & Editing; ABN: Methodology, Formal Analysis, Writing – Review & Editing; PK: Conceptualization, Methodology, Investigation, Supervision, Formal Analysis, Writing – Review & Editing.

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2.8 SUPPLEMENTAL MATERIAL

This supplemental material contains the following information:

- Participant Inclusion Criteria
- Flow of Participants
- Cross-Classified Variance Decomposition Models
- Additional Information for Main Analyses Testing Hypotheses
  - Explanation of Variables and Model Diagrams
  - Standardized Model Results
- Manipulation Check
- Supplemental Analyses

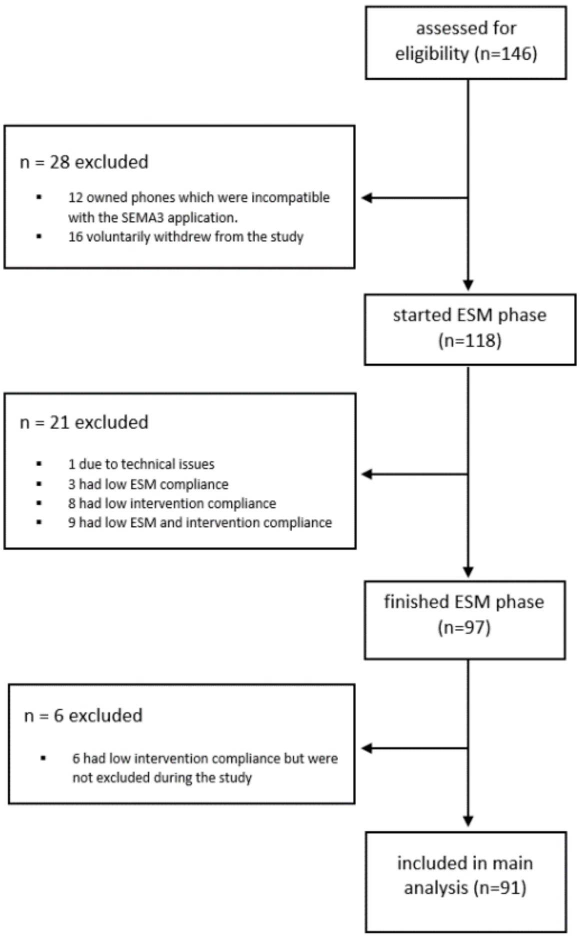
2.8.1. PARTICIPANT INCLUSION CRITERIA

Our inclusion criteria diverge from what we stated in our original study pre-registration as follows: the pre-registration does not mention vision, hearing, or mental health exclusions. Further, the pre-registration mentions prior mindfulness training experience as an exclusion, however, this was not applied. We instead measured previous meditation experience and practice frequency (see Table 1).

2.8.2 FLOW OF PARTICIPANTS

Figure S1

Flowchart of Participants



2.8.3 CROSS-CLASSIFIED VARIANCE DECOMPOSITION MODELS

Table S1

Cross-Classified Variance Decomposition Models

	Level 1 (within person/occasion)		Between Persons		Between Occasions	
Variable	Variance	VPC	Variance	VPC	Variance	VPC
Rumination	345.443	.519	319.940	.480	0.501	.001
NA	102.308	.317	215.595	.667	4.913	.015
Mindfulness	178.149	.370	302.015	.629	0.321	.001

Note. VPC = variance partition coefficient, NA = negative affect.

Results of empty or "null" cross-classified models used to estimate the proportion of variance in each of our ESM measures are shown in Table S1 (above). Results of these models indicated that less than 1% of the total variance in rumination and mindfulness, and less than 2% of the variance in NA was between occasions. In contrast, approximately 33-67% of the total variance in each outcome was at the between-person and within-person/occasion levels. In light of the negligible amount of variance at the between-occasion level, we opted to test our hypotheses using two-level models.

2.8.4 ADDITIONAL INFORMATION FOR MAIN ANALYSES TESTING HYPOTHESES

2.8.4.1 Explanation of Variables and Model Diagrams

The Figures S2-S10 (see below) include the latent decomposition, the within-person model, and the between-person model of our dynamics structural equation modeling (DSEM) analyses conducted as main analyses to test our hypotheses.

In the model diagrams, we label parameters as follows:

- ϕ = auto-regressive slope
- β = cross-regressive slope
- ψ = innovation variance

We include the following variables in our models, with subscripts i and t represent people and occasions, respectively:

- NA_{ti} = person i's negative affect score at occasion t
- RU_{ti} = person i's rumination score at occasion t
- MI_{ti} = a binary predictor, coded as 1 when the mindfulness intervention was delivered and 0 when the control task was delivered for each person i at each occasion t.
- $MI_{ti} * RU_{ti}$ = an interaction term calculated as the product of MI_{ti} and RU_{ti}

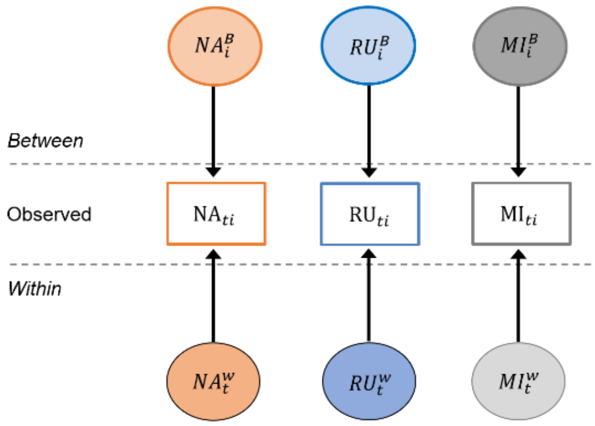
These observed variables are decomposed into orthogonal within and between person components using latent centering, as reflected by the superscripts w and b, e.g., the latent within and between components of NA_{ti} are NA_t^w and NA_i^b, respectively. However, latent centering is not possible when including interactions between an observed and a latent lagged variable, as in Model 3 (see below). Therefore, we used observed-mean centering in Model 3. To do so, we (1) person-mean centered RU, NA, and the mindfulness intervention using their observed person-specific means, (2) created the lag 1 variables for RU and NA using the person-mean centered variables, and (3) created the interaction term between these lagged variables and the person-mean centered mindfulness intervention variable. Consequently, in Model 3, we included the following observed person-mean centered variables (indicated by the superscript *pmc*):

- NA_{t-1}^{pmc} = person-mean centered negative affect at occasion $t-1$
- RU_{t-1}^{pmc} = person-mean centered rumination at occasion $t-1$
- MI_{t}^{pmc} = person-mean centered mindfulness intervention (vs. control task) delivered at occasion t
- $MI_{t}^{pmc} * NA_{t-1}^{pmc}$ = an interaction term calculated as the product of MI_{t}^{pmc} and NA_{t-1}^{pmc}
- $MI_{t}^{pmc} * RU_{t-1}^{pmc}$ = an interaction term calculated as the product of MI_{t}^{pmc} and RU_{t-1}^{pmc}

Model 1

Figure S2

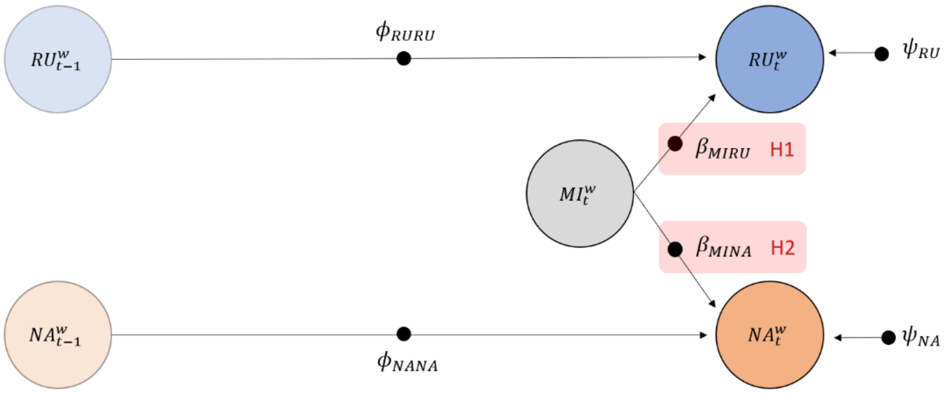
Latent Decomposition of Model 1



Note. RU = rumination, NA = negative affect, MI = mindfulness intervention, *W* = within-person component of DSEM model, *B* = between-person component of DSEM model, *i* = individual *i*, *t* = occasion *t*

Figure S3

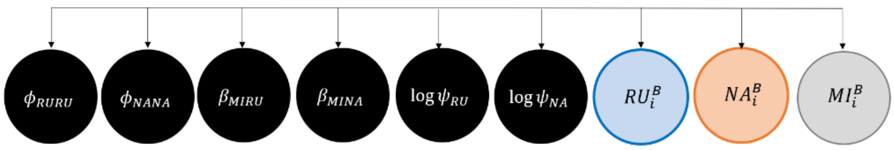
Within-Person Model of Model 1



Note. RU = rumination, NA = negative affect, MI = mindfulness intervention, w = within-person component of DSEM model, ϕ_{RURU} = autoregressive effect of rumination, ϕ_{NANA}= autoregressive effect of negative affect, β_{MIRU} = effect of mindfulness intervention at *t* on rumination at *t*, β_{MINA} = effect of mindfulness intervention at *t* on negative affect at *t*, ψ_{RU}= residual variance of rumination, ψ_{NA}= residual variance of negative affect. The filled circles indicate that the parameters are random.

Figure S4

Between-Person Model of Model 1

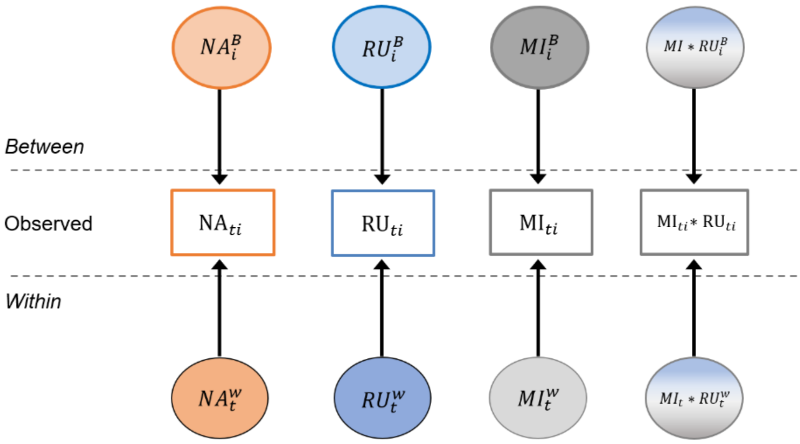


Note. RU = rumination, NA = negative affect, MI = mindfulness intervention, B = between-person component of DSEM model, i = individual i, ϕ_{RURU} = autoregressive effect of rumination, ϕ_{NANA}= autoregressive effect of negative affect, β_{RUNA} = cross-regressive effect of rumination at t on negative affect at t, β_{MINA} = effect of mindfulness intervention at t on negative affect at t, $\beta_{MI*RUNA}$= effect of the mindfulness intervention at t on the cross-regressive effect of rumination at t on negative affect at t, $log\ \psi_{RU}$= log-transformed residual variance of rumination, $log\psi_{NA}$= log-transformed residual variance of negative affect.

Model 2

Figure S5

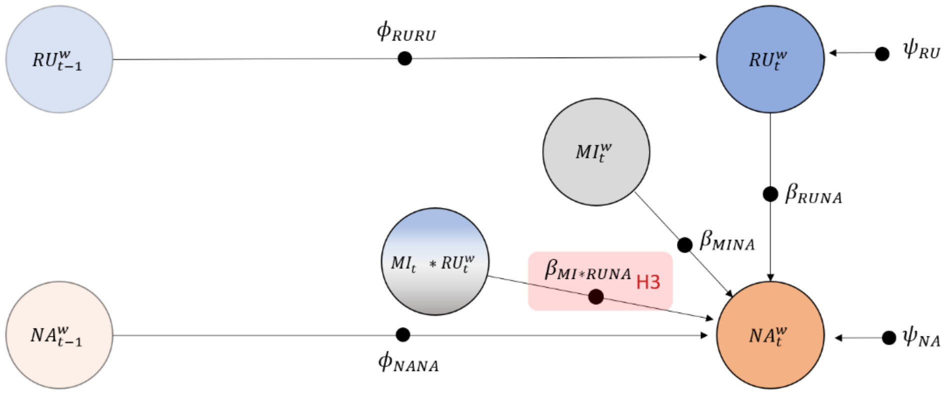
Latent Decomposition of Model 2



Note. RU = rumination, NA = negative affect, MI = mindfulness intervention, W = within-person component of DSEM model, B = between-person component of DSEM model, i = individual, t = occasion t.

Figure S6

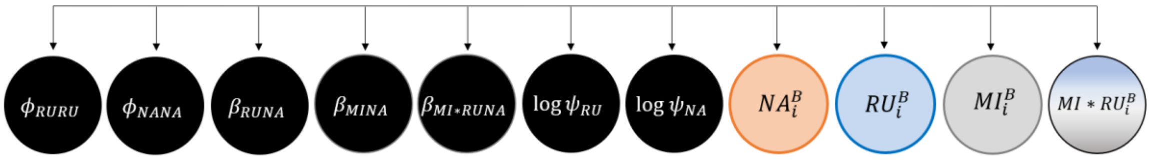
Within-Person Model of Model 2



Note. RU = rumination, NA = negative affect, MI = mindfulness intervention, w = within-person component of DSEM model, ϕ_{RURU} = autoregressive effect of rumination, ϕ_{NANA}= autoregressive effect of negative affect, β_{RUNA} = cross-regressive effect of rumination at t on negative affect at t, β_{MINA} = effect of mindfulness intervention at t on negative affect at t, $\beta_{MI*RUNA}$= effect of the mindfulness intervention at t on the cross-regressive effect of rumination at t on negative affect at t, ψ_{RU}= residual variance of rumination, ψ_{NA}= residual variance of negative affect. The filled circles indicate that the parameters are random.

Figure S7

Between-Person Model of Model 2

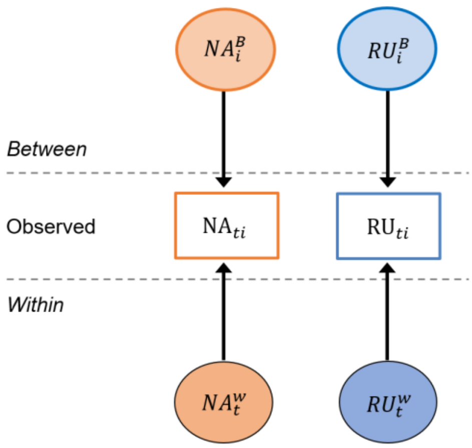


Note. RU = rumination, NA = negative affect, MI = mindfulness intervention, B = between-person component of DSEM model, i = individual i, ϕ_{RURU} = autoregressive effect of rumination, ϕ_{NANA}= autoregressive effect of negative affect, β_{RUNA} = cross-regressive effect of rumination at t on negative affect at t, β_{MINA} = effect of mindfulness intervention at t on negative affect at t, $\beta_{MI*RUNA}$= effect of the mindfulness intervention at t on the cross-regressive effect of rumination at t on negative affect at t, $log\psi_{RU}$= log-transformed residual variance of rumination, $\log\psi_{NA}$= log-transformed residual variance of negative affect.

Model 3

Figure S8

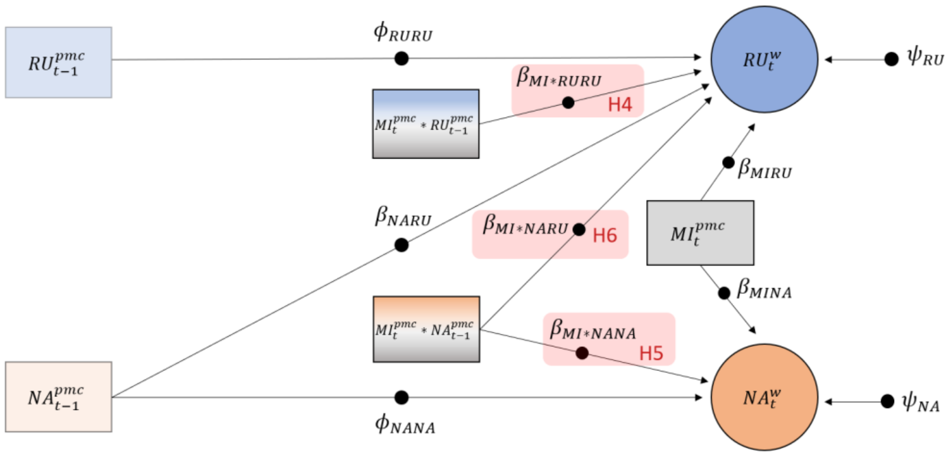
Latent Decomposition of Model 3



Note. RU = rumination, NA = negative affect, W = within-person component of DSEM model, B = between-person component of DSEM model, i = individual i, t = occasion t.

Figure S9

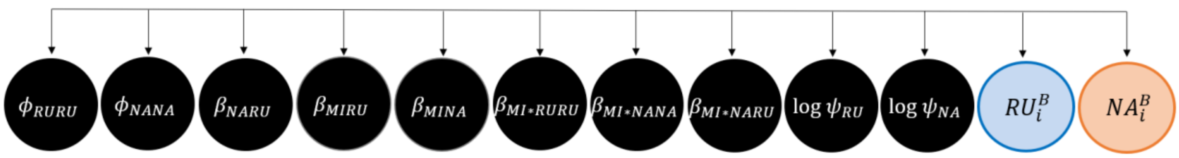
Within-Person Model of Model 3



Note. RU = rumination, NA = negative affect, MI = mindfulness intervention, *w* = within-person component of DSEM model, *pmc* = observed person-mean centered, ϕ_{RURU} = autoregressive effect of rumination, ϕ_{NANA} = autoregressive effect of negative affect, ϕ_{NARU} = cross-regressive effect of negative affect at *t*-1 on rumination at *t*, β_{MIRU} = effect of mindfulness intervention at *t* on rumination at *t*, β_{MINA}= effect of mindfulness intervention at *t* on negative affect at *t*, $\beta_{MI*NARU}$= effect of the mindfulness intervention on the cross-regressive effect of negative affect at *t*-1 on rumination at *t*, $\beta_{MI*RURU}$ = effect of the mindfulness intervention at *t* on the autoregressive effect of rumination, $\beta_{MI*NANA}$ = effect of the mindfulness intervention at *t* on the autoregressive effect of negative affect, ψ_{RU}= residual variance of rumination, ψ_{NA}= residual variance of negative affect. The filled circles indicate that the parameters are random.

Figure S10

Between-Person Model of Model 3



Note. RU = rumination, NA = negative affect, *B* = between-person component of DSEM model, *i* = individual *i*, ϕ_{RURU} = autoregressive effect of rumination, ϕ_{NANA}= autoregressive effect of negative affect, ϕ_{NARU} = cross-regressive effect of negative affect at *t*-1 on rumination at *t*, β_{MIRU} = effect of mindfulness intervention at *t* on rumination at *t*, β_{MINA}= effect of mindfulness intervention at *t* on negative affect at *t*, $\beta_{MI*RURU}$ = effect of the mindfulness intervention at *t* on the autoregressive effect of rumination, $\beta_{MI*NANA}$ = effect of the mindfulness intervention at *t* on the autoregressive effect of negative affect, $\beta_{MI*NARU}$= effect of the mindfulness intervention on the cross-regressive effect of negative affect at *t*-1 on rumination at *t*, $log\psi_{RU}$= log-transformed residual variance of rumination, $\log\psi_{NA}$= log-transformed residual variance of negative affect.

2.8.4.2 Standardized Model Results

Model 1

Table S2

Standardized Fixed Effects (median) of Model 1

	Estimate	*95% CI*	
Parameters		*Lower*	*Upper*
Autoregressive effects			
ϕ_{RURU}	0.204	0.177	0.232
ϕ_{NANA}	0.375	0.349	0.401
Effects of mindfulness intervention			
β_{MIRU}	-0.158	-0.189	-0.128
β_{MINA}	-0.114	-0.143	-0.085
Log residual variances			
ψ_{RU}	0.812	0.790	0.835
ψ_{NA}	0.740	0.715	0.764

Note. Intercept estimates are not included in the standardized output; CI = credible interval, RU = rumination, NA = negative affect, MI = mindfulness intervention, ϕ_{RURU}= autoregressive effect of rumination, ϕ_{NANA} = autoregressive effect of negative affect, β_{MIRU} = effect of mindfulness intervention at *t* on rumination at *t*, β_{MINA}= effect of mindfulness intervention at *t* on negative affect at *t*, ψ_{RU}= log transformed residual variance of rumination, ψ_{NA}= log transformed residual variance of negative affect.

Model 2

Table S3

Standardized Fixed Effects (median) of Model 2

Parameters	Estimate	95% CI Lower	95% CI Upper
Autoregressive effects			
ϕ_{RURU}	0.205	0.176	0.232
ϕ_{NANA}	0.317	0.292	0.341
Cross-regressive effects			
β_{RUNA}	0.268	0.236	0.297
(Interaction) Effects of mindfulness intervention			
β_{MINA}	-0.134	-0.197	-0.075
$\beta_{MI*RUNA}$	0.082	0.026	0.143
Log residual variances			
ψ_{RU}	0.920	0.907	0.934
ψ_{NA}	0.605	0.570	0.635

Note. Intercept estimates are not included in the standardized output; CI = credible interval, RU = rumination, NA = negative affect, MI = mindfulness intervention, ϕ_{RURU}= autoregressive effect of rumination, ϕ_{NANA} = autoregressive effect of negative affect, β_{RUNA}= cross-regressive effect of rumination at *t* on negative affect at *t*, β_{MINA} = effect of mindfulness intervention at *t* on negative affect at *t*, $\beta_{MI*RUNA}$= effect of the mindfulness intervention at *t* on the cross-regressive effect of rumination at *t* on negative affect at *t*, ψ_{RU}= log transformed residual variance of rumination, ψ_{NA}= log transformed residual variance of negative affect.

Model 3

Table S4

Standardized Fixed Effects (median) of Model 3

Parameters	Estimate	95% CI Lower	95% CI Upper
Autoregressive effects			
ϕ_{RURU}	0.155	0.124	0.184
ϕ_{NANA}	0.328	0.303	0.352
Cross-regressive effects			
ϕ_{NARU}	0.041	0.011	0.071
(Interaction) Effects of mindfulness intervention			
β_{MIRU}	-0.116	-0.143	-0.089
β_{MINA}	-0.064	-0.091	-0.038
$\beta_{MI*NARU}$	0.014	-0.014	0.044
$\beta_{MI*RURU}$	0.004	-0.027	0.031
$\beta_{MI*NANA}$	0.002	-0.026	0.030
Log residual variances			
ψ_{RU}	0.829	0.812	0.847
ψ_{NA}	0.810	0.792	0.828

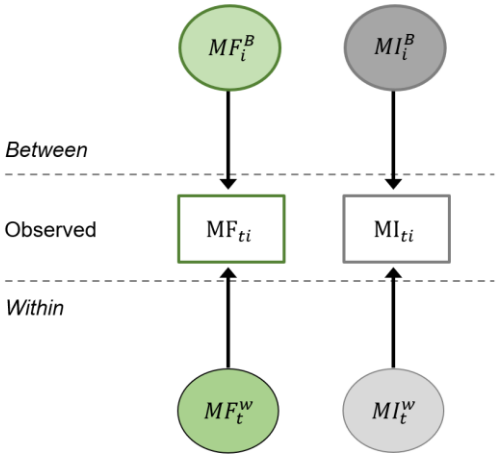
Note. Intercept estimates are not included in the standardized output; CI = credible interval, RU = rumination, NA = negative affect, MI = mindfulness intervention, ϕ_{RURU}= autoregressive effect of rumination, ϕ_{NANA} = autoregressive effect of negative affect, ϕ_{NARU} = cross-regressive effect of negative affect at t-1 on rumination at t, β_{MIRU}= effect of mindfulness intervention at t on rumination at t, β_{MINA}= effect of mindfulness intervention at t on negative affect at t, $\beta_{MI*NARU}$ = effect of the mindfulness intervention at t on the cross-regressive effect of negative affect at t-1on rumination at t, $\beta_{MI*RURU}$ $\beta_{MI*RURU}$ = effect of the mindfulness intervention at t on the autoregressive effect of rumination, $\beta_{MI*NANA}$ = effect of the mindfulness intervention at t on the autoregressive effect of negative affect, ψ_{RU}= log transformed residual variance of rumination, ψ_{NA}= log transformed residual variance of negative affect.

2.8.5 MANIPULATION CHECK

Figures S11-S13 include the latent decomposition, the within-person model, and the between-person model of the dynamics structural equation modeling (DSEM) analyses conducted as a manipulation check. For detailed model specification and results, see Mplus output files at https://osf.io/y3gnt/ in the folder "Momentary Mindfulness and Rumination"/"Code and Results"/"3_Manipulation Check".

Figure S11

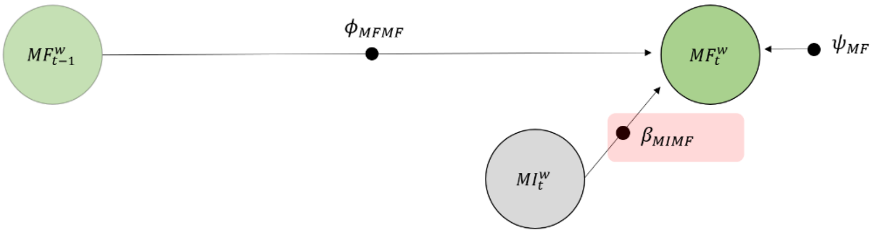
Latent Decomposition of DSEM Model Used as a Manipulation Check



Note. MF: state mindfulness; MI = mindfulness intervention, *W* = within-person component of DSEM model, *B* = between-person component of DSEM model, *i* = individual *i*, *t* = occasion *t*

Figure S12

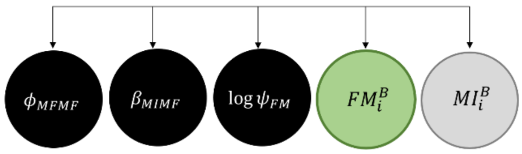
Within-Person Model of DSEM Model Used as a Manipulation Check



Note. MF: state mindfulness; MI = mindfulness intervention, W = within-person component of DSEM model, t = occasion t, ϕ_{MFMF} = autoregressive effect of state mindfulness, β_{MIMF} = effect of mindfulness intervention at t on state mindfulness at t, ψ_{MF}= residual variance of state mindfulness. The filled circles indicate that the parameters are random.

Figure S13

Between-Person Model of DSEM Model Used as a Manipulation Check



Note. MF: state mindfulness; MI = mindfulness intervention, B = between-person component of DSEM model, i = individual i, ϕ_{MFMF} = autoregressive effect of state mindfulness, β_{MIMF} = effect of mindfulness intervention at t on state mindfulness at t, $log\psi_{MF}$ = log transformed residual variance of state mindfulness.

2.8.6 SUPPLEMENTAL ANALYSES

We ran the following supplementary analyses (SA) to check the robustness of our findings to alternate model specifications:

- Alternate approaches to dealing with unequal time intervals:
  - **SA (a)**

    Models 1 & 2: we repeated these models using a continuous time indicator (hours passed since last survey) as the TINTERVAL variable. For detailed model specification and results, please see Table S6 & S7 and Mplus output files at https://osf.io/y3gnt/ in the folder "Momentary Mindfulness and Rumination"/"Code and Results"/"5_Supplemental Analyses"/"a TINTERVAL";
  - **SA (b)**

    Model 3: we repeated this model after replacing the observed score on the first occasion on each new day in lagged variables with a missing value to exclude "overnight lags". For detailed model specification and results, see Table S8 and Mplus output files at https://osf.io/y3gnt/ in the folder "Momentary Mindfulness and Rumination"/"Code and Results"/"5_Supplemental Analyses"/"b lag".
- Alternate approaches to dealing with intervention non-compliance:

- **SA (c)**

  We repeated Models 1-3 including data from *n*=6 participants who were excluded for high (>40%) non-compliance with the intervention after the completion of data collection. **This** led to a sample size of *N*=97 in these analyses. Note that data from participants excluded for intervention non-compliance *prior* to completion of the study will not be analyzed. For detailed model specification and results, see Table S6-S8 and Mplus output files at https://osf.io/y3gnt/ in the folder "Momentary Mindfulness and Rumination" /"Code and Results"/"5_Supplemental Analyses"/"c N=97";

- **SA (d)**

  We repeated Models 1-3 after removing all rows (ESM surveys) for which we had evidence of non-compliance with the intervention (i.e., where the total reaction time to the intervention/control prompt and the first 3 ESM items was <180000 ms). For detailed model specification and results, see Table S6-S8 and Mplus output files at https://osf.io/y3gnt/ in the folder "Momentary Mindfulness and Rumination"/"Code and Results"/"5_Supplemental Analyses"/"d intervention non-compliance".

– Including random residual covariance:

- **SA (e)**

  We repeated Models 1-3 including a random residual covariance among the Within level outcomes (NA and RU). Following Hamaker et al. (2018), we fixed the factor loadings for the latent factor representing the residual covariance (and freely estimate its variance), which restricts the random residual covariance to take either a positive or negative value for all individuals. Given that negative affect (NA) and rumination (RU) are known to be positively correlated, we restricted the random residual covariance to positive values. For detailed model specification and results, see Table S6-S8 and Mplus output files at https://osf.io/y3gnt/ in the folder “Momentary Mindfulness and Rumination”/”Code and Results”/”5_Supplemental Analyses”/”e random residual covariance”. Model 2 with covariance between the residual variances did not converge. Therefore, we do not report the results of this model in Table S7.

Table S5

Unstandardized Fixed Effects (median) from Model 1 for Supplementary Analyses

	(a) with continuous time indicator (TINTERVAL)			**(c)** *N*=97; *n*=6 participants with high non-compliance included			**(d)** intervention non-compliant beeps removed			**(e)** random residual covariance included		
	Estimate	*95% CI*		*Estimate*	*95% CI*		*Estimate*	*95% CI*		*Estimate*	*95% CI*	
Parameters		*Lower*	*Upper*		*Lower*	*Upper*		*Lower*	*Upper*		*Lower*	*Upper*
RU intercept	36.030	32.322	39.701	35.954	32.453	39.368	35.931	32.213	39.732	36.008	32.365	39.679
NA intercept	15.880	13.540	18.288	16.197	13.884	18.468	15.856	13.472	18.236	15.930	13.532	18.308
Autoregressive effects												
ϕ_{RURU}	0.213	0.158	0.267	0.201	0.149	0.251	0.208	0.151	0.263	0.207	0.155	0.258
ϕ_{NANA}	0.399	0.342	0.455	0.377	0.321	0.432	0.382	0.322	0.440	0.362	0.306	0.418
Effects of mindfulness intervention												
β_{MIRU}	-2.691	- 3.972	- 1.410	-2.653	-3.829	-1.495	-2.872	-4.124	-1.612	-2.198	-3.335	-1.048
β_{MINA}	-1.172	- 1.690	- 0.670	-1.217	-1.713	-0.736	-1.156	-1.667	-0.676	-0.880	-1.262	-0.516
Log residual variances												
ψ_{RU}	5.391	5.226	5.553	5.394	5.236	5.551	5.403	5.233	5.570	5.214	5.050	5.376
ψ_{NA}	3.852	3.622	4.084	3.920	3.688	4.142	3.851	3.613	4.084	2.703	2.293	3.044

Note. CI = credible interval, RU = rumination, NA = negative affect, MI = mindfulness intervention, ϕ_{RURU}= autoregressive effect of rumination, ϕ_{NANA} = autoregressive effect of NA, β_{MIRU} = effect of mindfulness intervention at t on rumination at t, β_{MINA}= effect of mindfulness intervention at t on NA at t, ψ_{RU}= log transformed residual variance of rumination, ψ_{NA}= log transformed residual variance of NA.

Table S6

Unstandardized Fixed Effects (median) from Model 2 for Supplementary Analyses

	(a) with continuous time indicator (TINTERVAL)			**(c)** *N*=97*; n*=6 participants with high non-compliance included			**(d)** intervention non-compliant beeps removed		
	Estimate	*95% CI*		*Estimate*	*95% CI*		*Estimate*	*95% CI*	
Parameters		*Lower*	*Upper*		*Lower*	*Upper*		*Lower*	*Upper*
RU intercept	35.936	32.250	39.597	35.899	32.439	39.411	35.860	32.157	39.514
NA intercept	16.736	13.798	19.719	16.238	13.885	18.604	15.930	13.550	18.349
Autoregressive effects									
ϕ_{RURU}	0.213	0.156	0.269	0.201	0.149	0.253	0.207	0.207	0.265
ϕ_{NANA}	0.327	0.272	0.381	0.321	0.268	0.375	0.322	0.266	0.379
Cross-regressive effects									
β_{RUNA}	0.163	0.120	0.206	0.163	0.124	0.205	0.159	0.117	0.202
(Interaction) Effects of mindfulness intervention									
β_{MINA}	-1.062	-1.694	-0.494	-1.139	-1.739	-0.543	-1.167	-1.808	-0.544
$\beta_{MI*RUNA}$	0.024	-0.014	0.061	0.022	-0.015	0.058	0.029	-0.010	0.069
Log residual variances									
ψ_{RU}	5.545	5.392	5.695	5.541	5.395	5.687	5.552	5.393	5.709
ψ_{NA}	3.695	3.466	3.928	3.775	3.552	3.999	3.689	3.453	3.922

Note. CI = credible interval, RU = rumination, NA = negative affect, MI = mindfulness intervention, ϕ_{RURU}= autoregressive effect of rumination, ϕ_{NANA} = autoregressive effect of NA, β_{RUNA}= cross-regressive effect of rumination at *t* on NA at *t*, β_{MINA} = effect of mindfulness intervention at *t* on NA at *t*, $\beta_{MI*RUNA}$= effect of the mindfulness intervention at *t* on the cross-regressive effect of rumination at *t* on NA at *t*, ψ_{RU}= log transformed residual variance of rumination, ψ_{NA}= log transformed residual variance of NA.

Table S7

Unstandardized Fixed Effects (median) of Model 3 for Supplementary Analyses

	(b) "overnight lags" excluded			**(c)** *N*=97; *n*=6 participants with high non-compliance included			**(d)** intervention non-compliant beeps removed			**(e)** random residual covariance included		
	Estimate	*95% CI*		*Estimate*	*95% CI*		*Estimate*	*95% CI*		*Estimate*	*95% CI*	
Parameters		*Lower*	*Upper*		*Lower*	*Upper*		*Lower*	*Upper*		*Lower*	*Upper*
RU intercept	36.083	31.763	40.530	35.938	31.877	39.969	35.865	31.419	40.163	35.988	31.523	40.455
NA intercept	17.085	13.471	20.674	17.239	13.807	20.627	16.909	13.405	20.424	16.953	13.479	20.487
Autoregressive effects												
ϕ_{RURU}	0.163	0.106	0.220	0.150	0.097	0.200	0.157	0.100	0.214	0.155	0.104	0.207
ϕ_{NANA}	0.368	0.307	0.432	0.339	0.281	0.396	0.340	0.281	0.399	0.346	0.281	0.410
Cross-regressive effects												
ϕ_{NARU}	0.047	-0.073	0.160	0.041	-0.060	0.136	0.028	-0.086	0.136	0.038	-0.067	0.140
(Interaction) Effects of mindfulness intervention												
β_{MIRU}	-4.002	-6.501	-1.523	-3.982	-6.249	-1.706	-4.265	-6.801	-1.743	-3.954	-6.506	-1.389
β_{MINA}	-1.396	-2.310	-0.519	-1.562	-2.445	-0.704	-1.454	-2.403	-0.529	-1.593	-2.606	-0.646
$\beta_{MI*NARU}$	0.054	-0.145	0.257	0.035	-0.136	0.211	0.041	-0.144	0.234	0.044	-0.133	0.218
$\beta_{MI*RURU}$	0.018	-0.086	0.120	0.018	-0.072	0.106	0.018	-0.086	0.127	0.015	-0.080	0.110
$\beta_{MI*NANA}$	0.009	-0.088	0.105	-0.011	-0.099	0.079	0.017	-0.079	0.113	0.014	-0.074	0.104
Log residual variances												
ψ_{RU}	5.445	5.258	5.633	5.433	5.254	5.615	5.442	5.246	5.640	5.179	4.952	5.397
ψ_{NA}	3.926	3.655	4.199	3.965	3.703	4.222	3.913	3.643	4.189	2.004	1.164	2.647

Note. CI = credible interval, RU = rumination, NA = negative affect, MI = mindfulness intervention, ϕ_{RURU}= autoregressive effect of rumination, ϕ_{NANA} = autoregressive effect of NA, ϕ_{NARU} = cross-regressive effect of NA at *t*-1 on rumination at *t*, β_{MIRU}= effect of mindfulness intervention at *t* on rumination at *t*, β_{MINA}= effect of mindfulness intervention at *t* on NA at *t*, $\beta_{MI*NARU}$ = effect of the mindfulness intervention at *t* on the cross-regressive effect of NA at *t*-1on rumination at *t*, $\beta_{MI*RURU}$ $\beta_{MI*RURU}$ = effect of the mindfulness intervention at *t* on the autoregressive effect of rumination, $\beta_{MI*NANA}$ = effect of the mindfulness intervention at *t* on the autoregressive effect of NA, ψ_{RU}= log transformed residual variance of rumination, ψ_{NA}= log transformed residual variance of NA.

CHAPTER 3:

ASSESSING THE IMMEDIATE EFFECTS OF DETACHED MINDFULNESS ON REPETITIVE NEGATIVE THINKING AND AFFECT IN DAILY LIFE: A RANDOMIZED CONTROLLED TRIAL

STUDY 2

The following paper was published in *Mindfulness*:

Bolzenkötter, T., Bürkner, P.-C., Zetsche, U., & Schulze, L. (2024). Assessing the immediate effects of detached mindfulness on repetitive negative thinking and affect in daily life: A randomized controlled trial. *Mindfulness, 15*, 1136–1148.

https://doi.org/10.1007/s12671-024-02350-5

Note that the formatting was adjusted to be consistent throughout the dissertation.

Pre-registration: This study was pre-registered at https://osf.io/rze64.

Data, Materials and Code availability: Data, analysis scripts, (additional) results, and further materials are available at https://osf.io/z2e83/.

3.1 ABSTRACT

Objectives: Repetitive negative thinking (RNT) is a problematic thinking style that is related to multiple mental disorders. Detached mindfulness is a technique of metacognitive therapy that aims to reduce RNT. Our study set out to investigate the immediate effects of detached mindfulness in daily life.

Methods: Participants with elevated trait RNT (n = 50) were prompted to engage in detached mindfulness exercises three times a day for 5 consecutive days. Immediate effects on RNT and affect were assessed 15 and 30 min after each exercise using experience sampling methodology. We compared the effects of this exercise phase to (1) a 5-day non-exercise baseline phase and (2) a different group of participants that engaged in an active control exercise (n = 50).

Results: Results of Bayesian multilevel models showed that, across groups, improvements in RNT, negative affect, and positive affect were stronger during the exercise phase than during the non-exercise baseline phase (RNT after 15 min: b = -0.26, 95% CI = [-0.38, -0.14]). However, the two exercise groups did not differ in these improvements (RNT after 15 min: b = 0.02, 95% CI = [-0.22, 0.27]). Thus, the detached mindfulness and the active control exercises resulted in similar effects on RNT and affect in daily life.

Conclusions: Results of this study imply that there was no additional benefit of having participants observe their thoughts detached and non-judgmentally, compared to excluding these assumed mechanisms of action as done for the active control group. We discuss possible reasons for the non-difference between the groups.

Keywords: Repetitive negative thinking, detached mindfulness, metacognitive therapy, randomized controlled trial, experience sampling methodology.

3.2 INTRODUCTION

When concerns or problems arise in life, it is natural to reflect on them extensively. When those thoughts continuously repeat themselves and are perceived as intrusive, unproductive, and difficult to control, they are called repetitive negative thinking (RNT; Ehring et al., 2011; Ehring & Watkins, 2008). RNT is a thinking style; it is characterized by the process of the thinking rather than its content. RNT is especially prevalent in depressive and generalized anxiety disorders, where the thinking is often described as rumination or worry, respectively (Ehring & Watkins, 2008). However, heightened levels of RNT have been observed across different mental disorders (Kircanski et al., 2018; Wahl et al., 2019) and are even predictive for their onset (Ehring & Watkins, 2008; Struijs et al., 2021). RNT has been proposed as a transdiagnostic process because of its relevance across various disorders (Ehring & Watkins, 2008). Studies using experience sampling methodology (ESM) showed that stronger momentary RNT is associated with stronger momentary negative affect (Kircanski et al., 2018). More importantly, ESM studies also highlighted that stronger momentary RNT results in a deterioration of negative affect at a later timepoint (Blanke et al., 2022; Stefanovic et al., 2021; Zetsche et al., 2023). Deteriorated affect can again trigger stronger RNT (Blanke et al., 2022; Hjartarson et al., 2021; Stefanovic et al., 2021) forming a vicious cycle. This vicious cycle might even be the building block of mental disorders on a micro-level. Indeed, Stefanovic et al. (2021) found that stronger associations between RNT and affect in daily life were predictive for future depressive symptoms. Therefore, it appears critical to provide people with strategies to interrupt RNT and to improve their affect in daily life because such strategies are likely to protect against mental disorders.

A number of interventions that aim to reduce RNT and its associated negative consequences have been developed (for an overview see for example: Teismann & Ehring, 2019; Topper et al., 2010). Interventions can take different approaches to reduce RNT. They may focus on modifying the actual content of thoughts or they may focus on changing a person's relationship to their thoughts. One example of the latter is metacognitive therapy. Metacognitive therapy assumes that emotional problems, such as depression or anxiety, are caused by an interplay of maladaptive metacognitions (e.g., "I have to worry in order to be prepared.") and the so-called cascading attentional syndrome (Wells, 2011). According to the cascading attentional syndrome, individuals are caught in unpleasant feelings because they do not see a negative thought as a spontaneous, transient, and often unimportant event, but focus on the content of that thought and start an inner dialog. Thus, they engage in RNT. By sticking to the thought and by continuously focusing on negative content, they dig themselves deeper into unpleasant feelings. To stop this harmful development, metacognitive therapy aims to reduce RNT with a technique called detached mindfulness (Wells, 2005).

Detached mindfulness is characterized by five elements (Wells, 2005): (1) meta awareness: noticing thoughts, (2) low conceptual processing: refraining from inner dialog and analysis of thought content, (3) low goal directed coping: refraining from changing or suppressing thoughts, (4) attentional detachment: not sticking to a thought and, (5) cognitive de-centering: realizing that thoughts are not facts but transient mental events.

Thus, detached mindfulness teaches to notice one's thoughts, while trying not to evaluate, control, suppress, or react to them. Instead, individuals train to move one's attention from one thought to the next, without getting entangled in its content and without trying to change the thought. As such, one is asked to view oneself as a non-judgmental observer, detached from the thoughts, and to realize that thoughts are merely mental events and do not necessarily represent the truth. It is assumed that when engaging in detached mindfulness, engaging in RNT is not possible because the two modes of processing are not compatible with one another (Wells, 2011).

Several studies examined whether detached mindfulness is effective in reducing different psychological problems. These studies either compared a detached mindfulness group with a control group, or they compared a detached mindfulness intervention with an active control intervention within the same individuals. A single session of detached mindfulness delivered in the laboratory reduced RNT-like thinking (i.e. anticipatory processing and pre-event rumination, respectively) in socially anxious participants compared to an active control intervention (Gkika & Wells, 2015) and compared to a passive control group (Modini & Abbott, 2018). Findings further demonstrated that participants' perception of their own thoughts changed. For example, a single session of detached mindfulness delivered in the laboratory made participants rate their thinking as more controllable and less distressing compared to an active control intervention (Caselli et al., 2016) and compared to a passive control group (Modini & Abbott, 2018). Several studies have also reported the effect of detached mindfulness on emotional outcomes. Detached mindfulness administered over multiple weeks in a group setting was related to stronger (Ahmadpanah et al., 2017) reductions in anxiety as well as stronger (Ahmadpanah et al., 2017) or similar (Ahmadpanah et al., 2018) reductions in depressive symptoms than an active control intervention. A single session of detached mindfulness delivered in the laboratory was related to similar reduction in anxiety compared to an active control group (Gkika & Wells, 2015) or no reduction in anxiety compared to a passive control group (Modini & Abbott, 2018). In sum, single sessions of detached mindfulness delivered in the laboratory and group treatments over multiple weeks appear beneficial to improve RNT and emotions (although results concerning emotional outcomes are mixed).

Detached mindfulness has many similarities with mindfulness-based interventions (MBIs). Both intend to change the focus of attention and observe ongoing experiences without trying to change them (Medvedev et al., 2022; Wells, 2011). Detached mindfulness and MBIs may differ in that detached mindfulness directs attention solely towards current thoughts, while MBIs may direct attention towards a broader range of aspects, such as emotions or surrounding sounds (Kabat-Zinn & Hanh, 2009; Wells, 2011). A crucial part of detached mindfulness is to achieve a metacognitive perspective by perceiving thoughts as detached from the self (Wells, 2011). While this metacognitive perspective is a defining element of detached mindfulness, MBIs not necessarily include detachment from experiences (Van Dam et al., 2018). In short, detached mindfulness may equivalently be applied in MBIs, but MBIs may incorporate aspects of mindfulness that are not part of detached mindfulness. For interested readers, Wells (2011) provides an extensive comparison of detached mindfulness as stemming from metacognitive therapy and other forms of mindfulness (see chapter 5.4).

Findings of MBIs align with those of detached mindfulness in the context of metacognitive therapy: Mindfulness appears as a promising candidate to reduce RNT and improve affect. For example, two meta-analyses demonstrate that MBIs reduce ruminative thinking to the same level as cognitive behavioral therapies (Mao et al., 2023; McCarrick et al., 2021). Additionally, digital MBIs were shown to improve RNT (Vargas-Nieto et al., 2024) and single inductions of mindfulness to reduce rumination and NA (however, results depend on the control induction used; Leyland et al., 2019).

However, most previous investigations of detached mindfulness either relied on multi-week interventions with pre-post comparisons of outcomes, which leave the immediate effects of the intervention unknown, or are conducted in a lab setting which limits their generalizability to daily life. Therefore, it remains unclear, how applying detached mindfulness in daily life affects the immediately following thought processes and affect. Thus, it is unclear whether approaching thoughts detached and non-judgmentally as one goes about in everyday life can interrupt RNT and improve affect.

The present study aimed to investigate whether manipulating how detached and mindful individuals approach their thoughts in certain moments in daily life impacts their experiences immediately after. For this purpose, we integrated detached mindfulness exercises as well as the assessment of its immediate effects into the daily lives of participants. Specifically, a smartphone app prompted participants to engage in a detached mindfulness exercise three times a day, over multiple days. The exercises consisted of audio files integrated into the smartphone app. We assessed levels of RNT, negative affect, and positive affect before as well as 15 and 30 min after each exercise using ESM. ESM repeatedly assesses individuals' momentary experiences in a natural environment (Myin-Germeys & Kuppens, 2022). This reduces memory bias that can exist in retrospective self-reports (Csikszentmihalyi & Larson, 1987; Zetsche et al., 2019). Therefore, ESM is ideal to validly and reliably capture how practicing detached mindfulness affects everyday experiences.

We recruited individuals with elevated trait RNT rather than a sample with a particular mental disorder. This ensured that all participants shared the same problematic thinking pattern, which is targeted by detached mindfulness. Individuals were randomized to either engage in detached mindfulness exercises or to engage in active control exercises. Both groups took part in a 5-day baseline phase during which they only reported momentary experiences via ESM (ESM-only) followed by a 5-day exercise phase during which they again reported momentary experiences but additionally completed guided exercises (ESM + exercises). This allowed us to compare the effects of the detached mindfulness exercises (1) with the ESM-only baseline phase and, (2) with the effects of the active control exercises. The exercises of the control group comprised similar "ingredients" as the detached mindfulness exercises. Participants in the control group also engaged in audio-guided exercises that included imagination of similar scenes as in the detached mindfulness group. However, the exercises of the control group excluded the specific detached mindfulness characteristics. Hereby, we aimed to dismantle the efficacy of the specific detached mindfulness mechanisms. We chose a 5-day (Wednesday to Sunday) data collection period for both phases to balance feasibility for our participants and to ensure consistency across both phases.

We expected that the exercise phase as compared to the baseline phase would be associated with a stronger immediate decrease of RNT, a stronger immediate decrease of negative affect, and a stronger immediate increase of positive affect from before (t0) to 15 min (t1) after the exercises as well as from before (t0) to 30 min (t2) after the exercises than the baseline phase. Further, we expected that these changes would be stronger in the detached mindfulness group than in the active control group.

3.3 METHOD

3.3.1 PARTICIPANTS

We recruited participants from the general population through online advertisements on eBay Kleinanzeigen, an online platform where users can offer and buy goods and local services. We stated that the goal of our study was to examine specific techniques for dealing with unpleasant thoughts and feelings. Inclusion criteria required participants to have at least moderate trait RNT (i.e., sum score of > 33 on the Perseverative Thinking Questionnaire; Ehring et al., 2011; compare Heckendorf et al., 2019 for cut-off), to be between 18 and 65 years old, to speak German fluently, and to have a smartphone with mobile data. Interested individuals were required to fill out an online screening questionnaire and register with their personal information if screened positive.

We included 107 participants and had complete data of 100 (50 detached mindfulness group, 50 active control group). Sample size determination is provided in the pre-registration. Figure 5 displays the participant flow. Participants' demographic characteristics can be found in Table 6.

Figure 5

Flow Chart of Participants

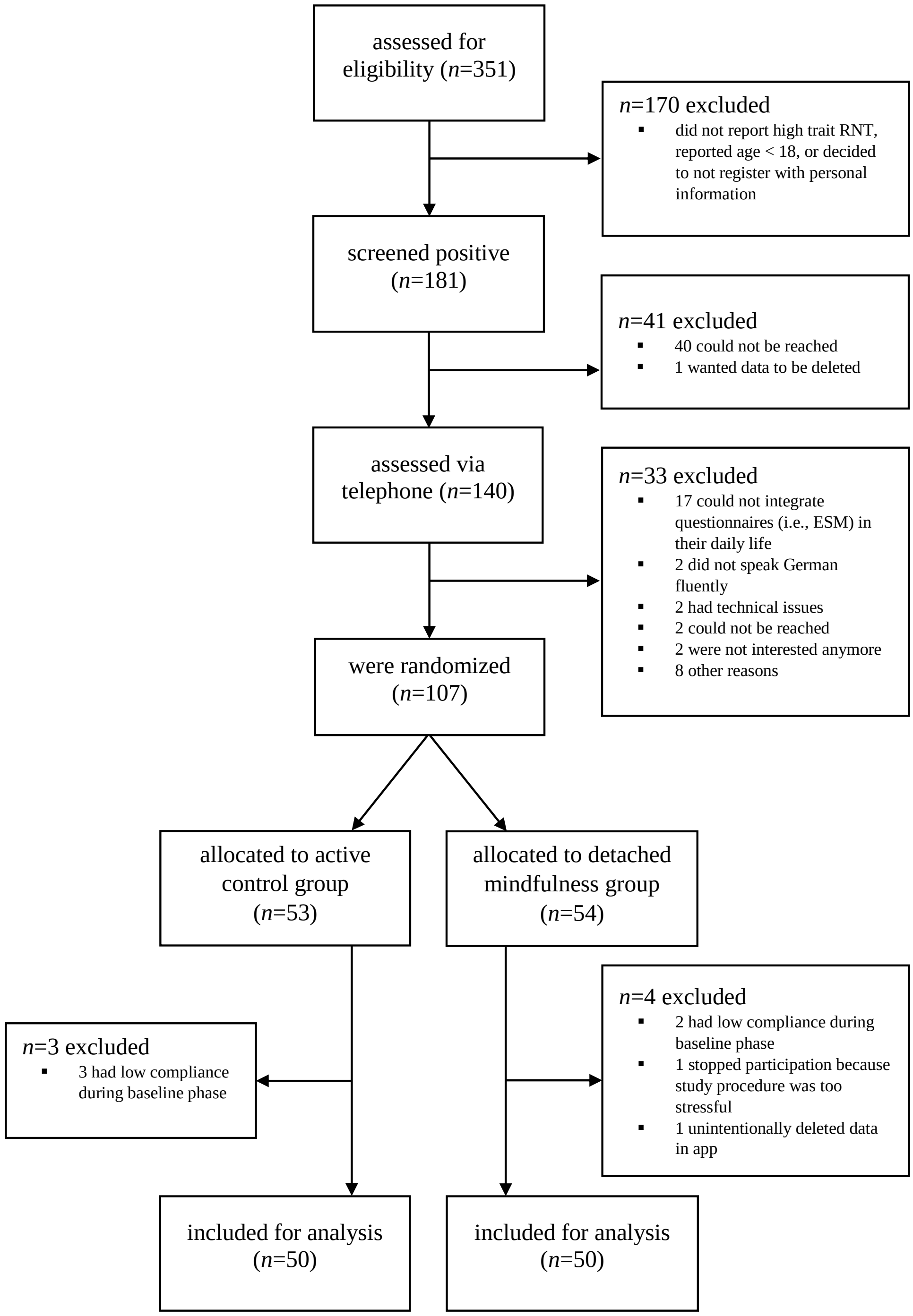


Table 6

Demographics and Clinical Characteristics of Participants

		Detached mindfulness group (*n* = 50)	Active control group (*n* = 50)
Age in years (*M, SD*)		33.8 (11.2)	34.2 (9.83)
Gender (*n*, %)			
	female	36 (72)	40 (80)
	male	12 (24)	9 (18)
	divers	2 (4)	1 (2)
Current psychotherapeutic/ psychiatric treatment (*n*, %)			
	no	35 (70)	42 (84)
	yes	12 (24)	5 (10)
	not specified	3 (6)	3 (6)
Prior experience with meditation or mindfulness (*M, SD*)		3.88 (2.03)	3.36 (1.96)

Note: Prior experience with meditation or mindfulness was measured on a scale from 1 (*not at all*) to 7 (*very much*). *M* = mean; *SD* = standard deviation; *n* = number of participants; % = percent of participants.

Participants gave informed consent prior to participation and were reimbursed at the end of the study. Reimbursement included a bonus of 10€ if participants answered more than 85% of all ESM assessments. Participants received a graphical feedback of their baseline phase ESM data if they wished. The study took place from September 2021 to April 2022.

3.3.2 PROCEDURE

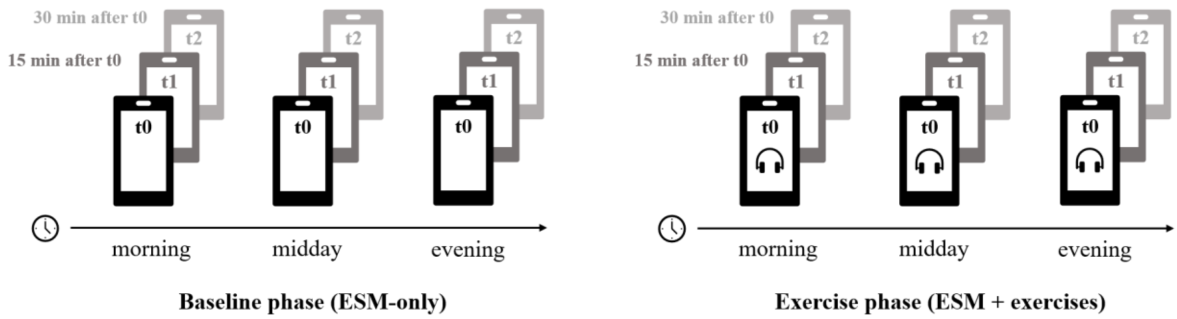
We explained the study procedure to participants in a telephone call. During this call, we also guided them to install the app for the experience sampling on their smartphones (m-path; Mestdagh et al., 2023) and tested it. Next, participants filled out an online pre-survey. Then, participants completed the baseline phase, followed by the exercise phase. At the end of the study, participants filled out an online post-survey. All surveys were assessed via the platform formR (Arslan et al., 2020).

3.3.2.1 Baseline phase (ESM-only)

The baseline phase lasted 5 days, always ran from Wednesday to Sunday, and included a maximum of nine daily assessments. Each day was split into three time-windows: morning (6am-11am), midday (12pm-5pm), evening (6pm-9pm). Participants self-selected 1.5-hr slots within each time-window to make participation more feasible. Participants received a set of three assessment during each slot. The first (t0) assessment was quasi-randomized within the first 30 min of each slot. The second (t1) assessment was scheduled 15 min after the t0 assessment was submitted; the third (t2) assessment was scheduled 30 min after the t0 assessment was submitted. We ensured that there were at least 90 min between the assessments of the different time-windows. The left-hand side of Figure 6 depicts the sampling scheme for a day during the baseline phase.

Figure 6

Daily Sampling Scheme for the Baseline and the Exercise Phase



Note. Both sampling schemes consist of the same ESM assessments. However, during the exercise phase, participants additionally completed the respective exercises at each t0 assessment

Participants received several reminders in case of unanswered assessments. Participants were excluded after the baseline phase if they had answered less than 60% of possible assessments.

3.3.2.2 Exercise phase (ESM + exercises)

The exercise phase included the same ESM assessments as the baseline phase and followed the same procedure: It lasted 5 days and always ran from Wednesday to Sunday. However, participants were additionally asked to complete the respective exercises three times a day. To do so, the audio file was displayed immediately after participants had answered the ESM questions of the t0 assessment. The t1 and t2 assessments followed 15 and 30 min after the end of the exercise. The right-hand side of Figure 6 depicts the sampling scheme for a day during the exercise phase.

3.3.3 MEASURES

3.3.3.1 Questionnaires

At the beginning and at the end of the study, we assessed several validated questionnaires with pre- and post-surveys. Detailed information on these questionnaires and their descriptive statistics can be found in the Supplemental material. In addition, we assessed participants' age, gender, whether they were currently in psychological and/or psychiatric treatment, and asked about previous experiences with meditation or mindfulness (see Table 1).

3.3.3.2 Experience Sampling Items

Participants answered 17 items during each ESM assessment, of which we used 14 (RNT and affect) for our main analysis. All questions were introduced by asking "How much do these statements apply to you at the moment?" and were presented in fixed order as listed below. A score for each of the following scales was created by calculating the mean across all items belonging to one scale. We calculated the within- and between-person reliability for each scale based on Geldhof et al. (2014).

RNT was assessed with 4 items: "The same negative thoughts keep going through my mind again and again.", "I get stuck on certain issues and can't move on.", "Thoughts come to my mind without me wanting them to.", and "How much do you feel weighed down by these thoughts at this moment?". All items were based on the process related items that Rosenkranz et al. (2020) developed for assessing RNT via ESM and were rated on a scale of 1 (*not at all*) to 7 (*very much*). We added the word "negative" in the first item. In our sample, the reliability of the RNT scale was very good (within-person: ω = 0.95 (95% *CI* = [0.95, 0.95]); between-person: ω = 0.98 (95% *CI* = [0.98, 0.99]).

Negative affect was assessed with 6 items: "I am [...]" sad, downhearted, afraid, nervous, upset, and irritable. All items were taken from the PANAS-X (German version: Grühn et al., 2010; Watson & Clark, 1994) and were rated on a scale of 1 (*not at all*) to 7 (*very much*). In our sample, the reliability of the negative affect scale was very good (within-person: ω = 0.83 (95% *CI* = [0.83, 0.84]); between-person: ω = 0.94 (95% *CI* = [0.92, 0.96]).

Positive affect was assessed with 4 items: "I am [...]" cheerful, happy, relaxed, and energetic. All items were taken from the PANAS-X (German version: Grühn et al., 2010; Watson & Clark, 1994) and were rated on a scale of 1 (*not at all*) to 7 (*very much*). In our sample, the reliability of the positive affect scale was very good (within-person: ω = 0.83 (95% *CI* = [0.82, 0.83]); between-person: ω = 0.92 (95% *CI* = [0.90, 0.95]).

3.3.3.3 Exercises

At the beginning of the study, participants were randomized to either the detached mindfulness group or the active control group. We created an excel sheet for the randomization including a random sequence of the two groups and participants were allocated according to this sequence. An error in the created sequence led to an imbalance of the number of participants in the two groups toward the end of the study. Therefore, the last five participants were allocated to the detached mindfulness group to reach balanced group sizes.

Before the exercise phase started, both groups received an instruction sheet that introduced and explained the detached mindfulness and active-control exercises, respectively. In both groups, the actual exercises consisted of audio files that included verbal instructions. Each exercise lasted about 4.5 min. The exercises started with the same introduction for both groups (e.g., invitation to close one's eyes if one wanted to) before continuing with the group-specific content.

In the detached mindfulness exercises, participants were asked to imagine either (1) clouds on the sky, (2) leaves on a river, or (3) trains at a station. Next, they were asked to imagine that the clouds, leaves, or trains are their thoughts. They were instructed to observe how their thoughts come and go without getting entangled in their content and without any attempts to change them. We created the scripts for the audio files based on the detached mindfulness exercise "Leaves floating in the river" from the manual cognitive behavioral therapy of depressive rumination (Teismann et al., 2017, p. 158) and adapted it to two other detached mindfulness metaphors (clouds on the sky, trains at a station) proposed by Wells (2005). All detached mindfulness characteristics (i.e., meta-awareness, low conceptual processing, low goal directed coping, attentional detachment, cognitive decentering; Wells, 2005) were integrated into the exercise instructions.

We used the detached mindfulness exercises as a template for the active control exercises. However, we aimed to exclude all specific detached mindfulness characteristics. In the active control exercises, participants were, therefore, also asked to imagine either (1) clouds on the sky, (2) leaves on a river, or (3) trains at a station. In contrast to the detached mindfulness group, there was no reference to participants' thoughts. Instead, participants received instructions to observe further elements in the imagined scene (e.g., flowers on a meadow).

We recorded all exercises once with a female voice (first author) and once with a male voice (colleague of first author). This resulted in six audio files per group. The order of the files was quasi-randomized. Each participant received each audio file of its group at least twice; no file was played twice in a row. The app tacked how long participants listened to each file. After the exercises, participants were asked: “How well were you able to implement the exercise?”, rated on a scale of 1 (not at all) to 7 (very much). If participants answered this question < 5, we asked for reasons using a multiple-choice item. All participants received a general instruction for the exercises of their group before they started with the exercise phase.

3.3.4 DATA ANALYSES

We estimated Bayesian linear multilevel models to examine our hypotheses. We used the R (R Core Team, 2021) package brms (Bürkner, 2017, 2018), which is based on Stan (Carpenter et al., 2017). Default priors of brms were chosen, which are not or only weakly informative, and thus only have negligible influence on the obtained results (Bürkner, 2017, 2018).

We calculated three models, one for each of the following dependent variables: RNT, negative affect, and positive affect. All models comprised the following factors as predictors: phase (factor levels: baseline, exercise), timepoint (factor levels: t0, t1, t2), group (factor levels: active control, detached mindfulness), and their respective interactions. The factors phase and timepoint varied within persons, whereas the factor group varied between persons. Lastly, we added the factor time-window (factor levels: morning, midday, evening) as a within-person predictor to model potential fluctuations of dependent variables within each day. All factors were effect coded. All models accounted for the existing three-level structure of our data, with beeps (Level 1) nested in days (Level 2) nested in persons (Level 3). The intercept as well as the predictors phase, timepoint, and their interaction were added as random effects in a way that represents the maximal random structure permitted by the study design (Barr et al., 2013; Heisig & Schaeffer, 2019). For more information on the exact model specifications, see the respective html file at https://osf.io/z2e83/.

Effects were considered clearly different from zero if the estimate's 95% credible interval (i.e., Bayesian confidence interval) did not include zero. Following Dushoof, Kain, & Bolker (2019), we use the term statistical clarity instead of statistical significance. The latter may be misleading and prone to misinterpretation. We also estimated the posterior probability (PP) that the respective effect is in the expected direction. PP values range from 0-1 with higher values indicating that the effect is going into the expected direction. We ensured that all models converged with Rhat = 1.00 and estimated effective sample sizes (ESS) of at least 400 for all estimates relevant for hypotheses testing (Vehtari et al., 2021).

We tested specific contrasts to examine our research questions. Firstly, we tested whether the change in RNT or affect from t0 and t1 and from t0 and t2 was stronger during the exercise phase than during the baseline phase. Next, we tested whether the above-mentioned changes were stronger for the detached mindfulness group than for the active control group (for more details see html file at https://osf.io/z2e83/).

3.5 RESULTS

3.5.1. COMPLIANCE

Compliance with experience sampling was very high. The two groups answered a similar percentage of beeps during the baseline phase (detached mindfulness group: M = 92.4, SD = 7.68, range = 64.4-100; active control group: M = 91.6, SD = 7.77, range = 66.7-100) as well as during the exercise phase (detached mindfulness group: M = 89.1, SD = 12.0, range = 51.1-100; active control group: M = 86.0, SD = 13.3, range = 48.9-100). However, both groups answered more beeps during the baseline phase than during the exercise phase, b = 4.47 (95% CI = [2.5, 6.44], $PP(b > 0) > 0.99$).

Compliance with the exercises was also very high. Participants of both groups started most of the 15 possible exercises (detached mindfulness group: M = 13.98, SD = 1.41, range: 9-15; active control group: M = 13.44, SD = 1.83, range: 8-15). If participants started an exercise, they also listened to a high percentage of the audio file (detached mindfulness group: M = 93.12, SD = 10.76, range: 59-100; active control group: M = 90.72, SD = 12.84, range: 43-100). This indicates that the exercises were actually conducted. On a scale from 1 (*not at all*) to 7 (*very much*), participants reported that they were able to implement the exercise rather well (detached mindfulness group: M = 5.08, SD = 1.12, range: 3-7; active control group: M = 4.88, SD = 1.26, range: 1-7).

3.5.2 EFFECTS OF EXERCISES ON IMMEDIATE RNT AND AFFECT

Table 7 displays the posterior means and credible intervals for RNT, negative affect, and positive affect for the two groups stratified by phase and timepoint.

Table 7

Posterior Means and 95% Credible Intervals for RNT, Negative Affect, and Positive Affect

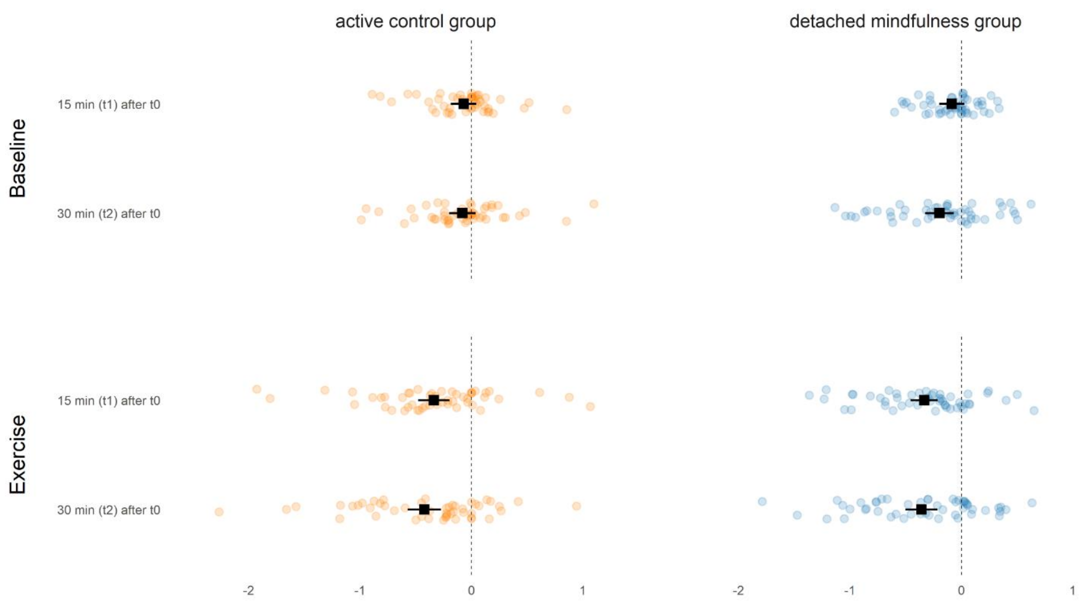
	Phase	Detached mindfulness group			Active control group		
		t0	t1	t2	t0	t1	t2
RNT (*M*, *CI*)	Baseline	3.51 (3.17, 3.85)	3.42 (3.07, 3.78)	3.31 (2.94, 3.68)	3.80 (3.42, 4.17)	3.73 (3.34, 4.12)	3.72 (3.33, 4.11)
	Exercise	3.20 (2.82, 3.57)	2.86 (2.49, 3.24)	2.84 (2.46, 3.22)	3.65 (3.31, 4.00)	3.32 (2.95, 3.68)	3.23 (2.86, 3.60)
Negative affect (*M*, *CI*)	Baseline	2.84 (2.52, 3.18)	2.84 (2.50, 3.19)	2.81 (2.47, 3.17)	3.00 (2.67, 3.33)	2.98 (2.65, 3.32)	2.98 (2.65, 3.32)
	Exercise	2.67 (2.33, 3.01)	2.55 (2.20, 2.89	2.53 (2.19, 2.88)	2.85 (2.51, 3.19)	2.68 (2.33, 3.03)	2.66 (2.31, 3.01)
Positive affect (*M*, *CI*)	Baseline	3.47 (3.18, 3.76)	3.49 (3.18, 3.79)	3.53 (3.22, 3.85)	3.73 (3.45, 4.00)	3.69 (3.40, 3.97)	3.68 (3.39, 3.96)
	Exercise	3.69 (3.37, 4.01)	3.85 (3.51, 4.18)	3.85 (3.51, 4.20)	3.64 (3.36, 3.92)	3.78 (3.49, 4.06)	3.77 (3.48, 4.06)

Note: Posterior means and credible intervals are based on the statistical models we used for hypothesis testing. *M* = posterior mean; *CI* = 95% credible interval (lower, upper).

As expected, there was a clearly stronger decrease in RNT from t0 to t1 during the exercise phase than during the baseline phase, across groups, b = -0.26 (95% CI = [-0.38, -0.14], $PP(b < 0) > 0.999$) – see Figure 7. Similarly, there was a clearly stronger decrease from t0 to t2 during the exercise phase than during the baseline phase, across groups, b = -0.25 (95% CI = [-0.38, -0.12], $PP(b < 0) > 0.999$). However, the stronger decrease from t0 to t1 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, b = 0.02 (95% CI = [-0.22, 0.27], $PP(b < 0) = 0.43$). Similarly, the stronger decrease from t0 to t2 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, b = 0.18 (95% CI = [-0.08, 0.44], $PP(b < 0) = 0.09$).

Figure 7

Changes in RNT Between t0 and t1 as well as t0 and t2 Stratified by Phase and Group



Note. Rectangular points represent posterior means, error bars represent 95% CIs based on statistical models. Circular points represent individual changes based on raw data.

As expected, there was a clearly stronger decrease in negative affect from t0 to t1 during the exercise phase than during the baseline phase, across groups, b = -0.14 (95% CI = [-0.22, -0.06], $PP(b < 0) > 0.999$). Similarly, there was a clearly stronger decrease from t0 to t2 during the exercise phase than during the baseline phase, across groups, b = -0.14 (95% CI = [-0.23, -0.05], $PP(b < 0) > 0.999$). However, the stronger decrease from t0 to t1 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, b = 0.03 (95% CI = [-0.14, 0.2], $PP(b < 0) = 0.35$). Similarly, the stronger decrease from t0 to t2 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, b = 0.06 (95% CI = [-0.12, 0.24], $PP(b < 0) = 0.26$).

As expected, there was a clearly stronger increase in positive affect from t0 to t1 during the exercise phase than during the baseline phase, across groups, b = 0.16 (95% CI = [0.07, 0.25], $PP(b > 0) > 0.999$). Similarly, there was a clearly stronger increase from t0 to t2 during the exercise phase than during the baseline phase, across groups, b = 0.14 (95% CI = [0.05, 0.23], $PP(b > 0) > 0.999$). However, the stronger increase from t0 to t1 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, b = -0.04 (95% CI = [-0.22, 0.15], $PP(b > 0) = 0.35$). Similarly, the stronger increase from t0 to t2 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, b = -0.08 (95% CI = [-0.27, 0.11], $PP(b > 0) = 0.25$).

3.5.3 SUPPLEMENTAL ANALYSES

We calculated several sensitivity analyses testing whether the listening duration, the success of implementation, being in psychotherapeutic and/or psychiatric treatment, and prior experiences with mindfulness had an impact on our findings. In short, results revealed that a longer listening duration and a higher success of implementation were related to stronger improvements in RNT and affect but that the groups did not differ in these effects. Moreover, our analyses on being in psychotherapeutic and/or psychiatric treatment and prior experiences with mindfulness, respectively, led to the same conclusions as our main analyses. This underlines the robustness of our findings because of consistent results across different analyses. Additionally, we ran exploratory analyses investigating non-judgmental acceptance as dependent variable and longer-term effects of the exercises (i.e., day to day changes in levels of RNT and affect before each exercise; pre- to post-changes in trait RNT and trait mindfulness). See Supplemental material for details of all respective analyses and results.

3.6 DISCUSSION

This study examined how applying short sequences of detached mindfulness in one's daily life influences immediate thought processes and affect. Specifically, we offered participants with elevated trait RNT multiple detached mindfulness exercise in a real-life environment and assessed its immediate effects on the transdiagnostic constructs RNT and affect. Importantly, this study comprised two different control conditions, namely a non-exercise baseline phase as well as a control group that engaged in active control exercises.

Results showed that, across both groups, there were stronger immediate changes during the exercise phase than during the baseline phase. Thus, participants' RNT and affect improved more strongly after they engaged in either the detached mindfulness or active control exercises than when they did not engage in them and instead engaged in what might be understood as their default mode of processing. The groups did not differ in these immediate changes, however. Thus, the improvements in the detached mindfulness group were not meaningfully different from the ones in the active control group.

This study focused on the effects of approaching thoughts detached and non-judgmentally. For this reason, our active control group received exercises that comprised similar ingredients as the detached mindfulness exercises but without the specific mechanism of detached mindfulness. In our view, such a procedure is important to dismantle different mechanisms that might contribute to change thought processes and affect. Our results failed to show a superiority of the detached mindfulness exercises. This implies that, in our study, there was no additional benefit of having participants observe their thoughts detached and non-judgmentally, compared to excluding these assumed mechanisms of action of detached mindfulness as done for the active control group.

Most previous studies did not only remove the detached mindfulness ingredients from their active control condition as we did, but included other potential mechanism of action in them (e.g., used a cognitive behavioral control intervention). Moreover, no previous study investigated the immediate effects of detached mindfulness in daily life. Thus, direct comparison with our finding is difficult. However, some studies assessed the effects of a single session of detached mindfulness delivered in the laboratory or multiple sessions of detached mindfulness delivered in a group setting and compared these to an active control condition. Those studies produced mixed results, depending on the outcome at focus and the kind of control condition. Specifically, these studies found no differences between detached mindfulness and the active control conditions with respect to depressive symptoms (multiple sessions in group setting; control condition: stress management training; Ahmadpanah et al., 2018) and anxiety (single session in laboratory; control condition: cognitive behavioral intervention; Gkika & Wells, 2015). On the other hand, detached mindfulness was more effective than the active control conditions with respect to anticipatory processing (single session in laboratory; control condition: cognitive behavioral intervention; Gkika & Wells, 2015) and anxiety and depression (multiple sessions in group setting; control condition: leisure activities; Ahmadpanah et al., 2017). Our study extends this existing knowledge about detached mindfulness by analyzing its immediate effects in a daily life context. Our findings of non-difference between the groups are also reflected in the mindfulness literature outside of metacognitive therapy. Costa & Barnhofer (2016) compared a mindfulness intervention to a guided imagery exercise that is comparable to our active control intervention. Both conditions reduced difficulties in emotion regulation and depressive symptoms after 1 week of training. Similarly, meta-analytic results of MBIs show a similar pattern: MBIs are primarily superior when compared to passive control conditions, but results are mixed when the control conditions are active (Goldberg et al., 2022; Mao et al., 2023). As the choice of control conditions is essential to the likelihood of finding an effect and, importantly, to the conclusions that can be drawn from a study, we paid close attention to the design of our control condition. We aimed to carefully dismantle the impact of specific detached mindfulness characteristics by holding non-specific characteristics (e.g., expectations towards the exercises, mode of exercise delivery, imagined scenery in the exercises) constant across the detached mindfulness and active control exercises. Through this approach, our findings contribute to the knowledge about the efficacy of detached mindfulness as one technique of metacognitive therapy: Our findings suggest that the specific detached mindfulness characteristics do not provide additional immediate benefits to RNT and affect compared to the control group. This is at least true for our implementation of detached mindfulness in the exercises and the chosen study design.

Given the lack of differences between the effects of the detached mindfulness group and the active control group, it is difficult to determine what mechanisms drove the changes during the exercise phase compared to the baseline phase. We can speculate about possible reasons. Firstly, the changes in both groups could simply be the result of demand effects. We informed participants of both groups that their exercises might be helpful in dealing with unpleasant thoughts. This could have elicited expectations that led to the similar changes in RNT and affect. Secondly, both exercises include a relaxation component. Participants of both groups were instructed to find a quiet place for the exercise and calm down. Additionally, instructions of both groups included the imagination of a predominantly pleasant scene. This might have made participants of both groups relax, thus leading to similar changes in outcomes. Thirdly, changes might have been induced by distraction. The exercises asked participants to imagine a certain scene. Thereby, attention of participants might have been drawn away from current negative thoughts or feelings. Previous research has shown that such distraction can reduce unpleasant experiences, especially when used in place of rumination (Denson et al., 2012; Huffziger & Kuehner, 2009; Nolen-Hoeksema et al., 2008). Similarly, meta-analytic results showed that mindfulness inductions were equally effective in reducing rumination as distraction (Leyland et al., 2018).

Limitations and Future Research. Our findings have to be interpreted considering the following restrictions. Findings apply to brief exercises (i.e., duration less than 5 min). Future studies may investigate whether differences between the exercise groups emerge when detached mindfulness is practiced with more intense exercises. Moreover, we used a sample of participants with elevated trait RNT. Future studies could examine whether the same results are found for clinical samples. Our participants engaged in detached mindfulness that originates from metacognitive therapy (Wells, 2011). Detached mindfulness may also be part of MBIs. However, the present results may not apply to other forms of mindfulness exercises used within MBIs. Lastly, it is possible that our sample size was too small to detect potential subtle differences between the groups. Future studies could use larger samples or, alternatively, employ a micro-randomized design. In micro-randomized trials, each participant receives both the intervention and the control on different occasions (see Bolzenkötter et al., 2024 for an application of a micro-randomized trial; see Klasnja et al., 2015 for a description of the micro-randomized trial design). This allows for within-person comparisons of conditions and thereby requires smaller samples than between-person comparisons (Klasnja et al., 2015).

Our study also has many strengths. First, detached mindfulness was repeatedly examined in a real-life setting which increases ecological validity and reliability (Csikszentmihalyi & Larson, 1987). Second, the assessment of outcomes via ESM reduces memory bias (Csikszentmihalyi & Larson, 1987). Third, the smartphone app tracked participants' compliance. This provides support that participants actually engaged in the exercises. One of the most important strengths of our study is, however, that we included two different control conditions. This enabled us to not only compare the effects of detached mindfulness to participants' default mode of processing but also to a control condition that was meant to equal the detached mindfulness exercises except for its assumed mechanisms of action. This approach allowed us to more confidently state that, in our sample and in the way we implemented the detached mindfulness exercises, the assumed mechanisms of detached mindfulness did not have an effect that goes beyond the one of our carefully designed control exercises.

RNT is a problematic thinking style that is related to different mental disorders. Detached mindfulness is one technique of metacognitive therapy that aims to reduce RNT. This study set out to investigate the immediate effects of practicing detached mindfulness in daily life. Results showed that both the detached mindfulness and active control exercises were related to improvements in immediate RNT, negative affect, and positive affect when compared to the non-exercise baseline phase. However, the two exercise groups did not differ. Thus, the detached mindfulness and the active control exercises resulted in similar effects. Finding effective strategies to change RNT in daily life remains a challenging but worthwhile task as it presents the opportunity to eliminate the breeding ground for multiple mental disorders (Topper et al., 2010).

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3.8 DECLARATIONS

Conflict of interest: The authors declare that they have no conflict of interest.

Ethical approval: The study was approved by the Ethics Committee of Freie Universität Berlin (no. 014.2021).

Informed Consent: All participants gave informed consent prior to participation.

Author contributions: Teresa Bolzenkötter: Conceptualization, Methodology, Investigation, Formal analysis, Writing - Original Draft, Writing - Review & Editing, Supervision, Funding acquisition. Paul-Christian Bürkner: Methodology, Writing - Review & Editing. Ulrike Zetsche: Conceptualization, Methodology, Formal analysis, Writing - Review & Editing, Supervision. Lars Schulze: Conceptualization, Methodology, Formal analysis, Writing - Review & Editing, Supervision, Funding acquisition.

Data, Materials and Code availability: Data, analysis scripts, (additional) results, and further materials, such as a list of all measures assessed and the exercises used, are available on the Open Science Framework at: https://osf.io/z2e83/.

Preregistration: This study was preregistered (see: https://osf.io/rze64).

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Use of Artificial Intelligence: The authors declare that no artificial intelligence tools were used to prepare this manuscript.

3.9 SUPPLEMENTARY MATERIALS

This supplementary material contains the following information:

- Questionnaires Pre- and Post-Survey
- Sensitivity Analyses
    - Influence of Listening Duration
    - Influence of Success of Implementation
    - Influence of Being in Treatment
    - Influence of prior experience with mindfulness or meditation
- Exploratory Analyses
    - Effects on Non-Judgmental Acceptance
    - Day to day changes in levels of RNT and affect before each exercise
    - Pre to post changes in trait RNT and trait mindfulness

3.9.1 QUESTIONNAIRES PRE- AND POST-SURVEY

At the beginning of the study (pre-survey), we assessed several validated questionnaires in order to characterize the sample. The pre-survey assessed depressive symptoms, symptoms of generalized anxiety disorder, trait repetitive negative thinking, and trait mindfulness. Trait repetitive negative thinking and trait mindfulness were also assessed at the end of the study (post-survey).

Depressive symptoms Depressive symptoms were assessed with the Patient Health Questionnaire-8 (PHQ-8; Kroenke et al., 2009; German version of PHQ-9 which has equivalent diagnostic accuracy: Martin et al., 2006). This measure has eight items that are answered on a scale from 0 (*not at all*) to 3 (*nearly every day*). In our sample, the reliability of the PHQ-8 was good (ω = 0.82 (95% *CI* = [0.76, 0.88])).

Symptoms of generalized anxiety disorder Symptoms of generalized anxiety disorder were assessed with the Generalized Anxiety Disorder Questionnaire-7 (GAD-7; German version: Löwe et al., 2008; Spitzer et al., 2006). This measure has seven items that are answered on a scale from 0 (*not at all*) to 3 (*nearly every day*). In our sample, the reliability of the GAD-7 was good: ω = 0.83 (95% *CI* = [0.77, 0.89]).

Trait repetitive negative thinking Trait repetitive negative thinking was assessed with the Repetitive Thinking Questionnaire-10 (RTQ-10; McEvoy et al., 2010; German version by S. Schmidt, C. Heinzel, personal communication, April 30, 2021). This measure has 10 items that are answered on a scale from 0 (*not true at all*) to 5 (*very true*). In our sample, the reliability of the RTQ-10 was good: RTQ-10_{pre}: ω = 0.86 (95% *CI* = [0.81, 0.91]); RTQ-10_{post}: ω = 0.87 (95% *CI* = [0.82, 0.92]).

Trait mindfulness Trait mindfulness was assessed with the Five Facets Mindfulness Questionnaire (FFMQ; Baer et al., 2006; German version: Michalak et al., 2016). This measure has 24 items that are answered on a scale from 1 (*never or very rarely true*) to 5 (*very often or always true*). In our sample, the reliability of the FFMQ was good: $FFMQ_{pre}$: ω = 0.89 (95% *CI* = [0.84, 0.93]); $FFMQ_{post}$: ω = 0.93 (95% *CI* = [0.91, 0.95]).

For each questionnaire, a sum-score was created. Table S14 depicts descriptive statistics of the measures assessed during the pre- and post-survey.

Figure S14

Demographics and clinical characteristics of participants

		Detached mindfulness group (*n* = 50)		Active control group (*n* = 50)	
Age in years (*M, SD*)		33.8 (11.2)		34.2 (9.83)	
Gender (*n*, %)					
	female	36 (72)		40 (80)	
	male	12 (24)		9 (18)	
	divers	2 (4)		1 (2)	
Current psychotherapeutic/ psychiatric treatment (*n*, %)					
	no	35 (70)		42 (84)	
	yes	12 (24)		5 (10)	
	not specified	3 (6)		3 (6)	
Prior experience with meditation or mindfulness (*M, SD*)		3.88 (2.03)		3.36 (1.96)	
Questionnaires (*M, SD*)		Pre	Post	Pre	Post
	PHQ-8	9.86 (4.51)		10.4 (4.58)	
	GAD-7	9.76 (3.99)		9.66 (4.77)	
	RTQ-10	34.8 (7.03)	33.4 (7.84)	35.4 (7.18)	36.9 (6.58)
	FFMQ	120 (18.3)	125 (21.1)	118 (20.0)	117 (21.5)

Note: *M* = mean; *SD* = standard deviation; n = number of participants; % = percent of participants; pre = pre-survey at the beginning of the study; post = post-survey at the end of the study; PHQ-8 = Patient Health Questionnaire-8; GAD-7 = Generalized Anxiety Disorder Questionnaire-7; RTQ-10 = Repetitive Thinking Questionnaire-10; FFMQ: Five Facet Mindfulness Questionnaire. Prior experience with meditation or mindfulness was measures on a scale from 1 (*not at all*) to 7 (*very much*).

3.9.2 SENSITIVITY ANALYSES

3.9.2.1 Influence of Listening Duration

Participants did not always listen to the complete audio-files. We explored whether how long participants listened to the exercises[4] was related to the effects of the exercise and whether the groups differed in these relationships.

3.9.2.1.1 Analysis

We estimated three Bayesian linear multilevel models with a 2-level structure (beeps nested in persons), one for each of the following dependent variables: RNT, negative affect, and positive affect. Predictor variables were timepoint (t0 vs. t1 vs. t2), group (active control vs. detached mindfulness), and a new metric variable representing the actual listening duration (replacing the predictor *phase* in the original models). This new variable (i.e., audio_duration_perc_cut_bi_c) was set to zero for all assessments of the baseline phase, indicating that the participants did not listen to any exercise. The variable was set to the actual listening duration in percent for each assessment in the exercise phase. We centered the variable by subtracting -50 from all values to make the interpretation for meaningful.

We tested specific contrasts to examine our research questions. Firstly, we tested whether the differences between t0 and t1 or between t0 and t2, respectively, were clearly more negative (for RNT and negative affect; indicating a stronger decrease), or more positive (for positive affect; indicating a stronger increase), when the listening duration was 1SD above the mean than when it was 1SD below the mean. Next, we tested whether the above-mentioned differences were stronger for the detached mindfulness group than for the active control group.

4 During the exercise phase, some participants listened to more than 100% of the audio files (e.g., 115%; indicating that they started the audio file again after it was finished). We set the percentages of these 71 occasions (5% of all audio files listened to) to 100%.

For more information on the specific contrasts as well as the exact model specifications and the convergence of the models, see the respective html file at https://osf.io/z2e83/.

3.9.2.1.2 Results

RNT. RNT decreased clearly stronger from t0 to t1 when the listening duration was 1SD above the mean than when it was 1SD below the mean, across groups, $b = -0.26$ (95% *CI* = [-0.38, -0.14], $PP(b < 0) > 0.999$). Similarly, RNT decreased clearly stronger from t0 to t2 when the listening duration was 1SD above the mean than when it was 1SD below the mean, across groups, $b = -0.23$ (95% *CI* = [-0.36, -0.1], $PP(b < 0) > 0.999$). However, the stronger decrease from t0 to t1 when the listening duration was 1SD above the mean than when it was 1SD below the mean did not differ between the detached mindfulness and the active control group, $b = 0.03$ (95% *CI* = [-0.21, 0.27], $PP(b < 0) = 0.42$). Similarly, the stronger decrease from t0 to t2 when the listening duration was 1SD above the mean than when it was 1SD below the mean did not differ between the detached mindfulness and the active control group, $b = 0.18$ (95% *CI* = [-0.08, 0.44], $PP(b < 0) = 0.09$).

Negative affect. Negative affect decreased clearly stronger from t0 to t1 when the listening duration was 1SD above the mean than when it was 1SD below the mean, across groups, $b = -0.14$ (95% *CI* = [-0.23, -0.06], $PP(b < 0) > 0.999$). Similarly, RNT decreased clearly stronger from t0 to t1 when the listening duration was 1SD above the mean than when it was 1SD below the mean, across groups, $b = -0.13$ (95% *CI* = [-0.23, -0.04], $PP(b < 0) > 0.999$). However, the stronger decrease in negative affect from t0 to t1 when the listening duration was 1SD above the mean than when it was 1SD below the mean did not differ between the detached mindfulness and the active control group, $b = 0.03$ (95% *CI* = [-0.14, 0.2], $PP(b < 0) = 0.38$). Similarly, the stronger decrease in negative affect from t0 to t2 when the listening duration was 1SD above the mean than when it was 1SD below the mean did not differ between the detached mindfulness and the active control group, $b = 0.06$ (95% *CI* = [-0.13, 0.24], $PP(b < 0) = 0.27$).

Positive affect. Positive affect increased clearly stronger from t0 to t1 when the listening duration was 1SD above the mean than when it was 1SD below the mean, across groups, $b = 0.16$ (95% *CI* = [0.07, 0.25], $PP(b > 0) > 0.999$). Similarly, positive affect increased clearly stronger from t0 to t1 when the listening duration was 1SD above the mean than when it was 1SD below the mean, across groups, $b = 0.14$ (95% *CI* = [0.04, 0.23], $PP(b > 0) > 0.999$). However, the stronger increase in positive affect from t0 to t1 when the listening duration was 1SD above the mean than when it was 1SD below the mean did not differ between the detached mindfulness and the active control group, $b = -0.06$ (95% *CI* = [-0.24, 0.12], $PP(b > 0) = 0.26$). Similarly, the stronger increase from t0 to t1 in positive affect when the listening duration was 1SD above the mean than when it was 1SD below the mean did not differ between the detached mindfulness and the active control group, $b = -0.10$ (95% *CI* = [-0.28, 0.09], $PP(b > 0) = 0.16$).

3.9.2.2 Influence of Success of Implementation

After each exercise, participants were asked how well they had been able to implement the exercise. We explored whether the success of implementation was related to the effects of the exercise and whether the groups differed in these relationships.

3.9.2.2.1 Analysis

We estimated three Bayesian linear multilevel models with a 2-level structure (beeps nested in persons), one for each of the following dependent variables: RNT, negative affect, and positive affect. Predictor variables were timepoint (t0 vs. t1 vs. t2), group (active control vs. detached mindfulness), and a new metric variable representing the success of implementation (replacing the predictor *phase* in the original models). This new variable (i.e., umsetzen_bi_c) was set to 1 for all assessments in the baseline phase.

The variable was set to participants' actual success rating for each assessment in the exercise phase. We centered the variable by subtracting -4 from all values to make the interpretation for meaningful.

We tested specific contrasts to examine our research questions. Firstly, we tested whether the differences between t0 and t1 or between t0 and t2, respectively, were clearly more negative (for RNT and negative affect; indicating a stronger decrease), or more positive (for positive affect; indicating a stronger increase), when the success of implementation was 1SD above the mean than when it was 1SD below the mean. Next, we tested whether the above-mentioned differences were stronger for the detached mindfulness group than for the active control group.

For more information on the specific contrasts as well as the exact model specifications and the convergence of the models, see the respective html file at https://osf.io/z2e83/.

3.9.2.2.2 Results

RNT. RNT decreased clearly stronger from t0 to t1 when the success of implementation was 1SD above the mean than when it was 1SD below the mean, across groups, b = -0.31 (95% CI = [-0.43, -0.2], $PP(b < 0) > 0.999$). Similarly, RNT decreased clearly stronger from t0 to t1 when the success of implementation was 1SD above the mean than when it was 1SD below the mean, across groups, b = -0.3 (95% CI = [-0.43, -0.18], $PP(b < 0) > 0.999$). However, the stronger decrease from t0 to t1 when the success of implementation was 1SD above the mean than when it was 1SD below the mean did not differ between the detached mindfulness and the active control group, b = -0.01 (95% CI = [-0.23, 0.23], $PP(b < 0) = 0.52$). Similarly, the stronger decrease from t0 to t2 when the success of implementation was 1SD above the mean than when it was 1SD below the mean did not differ between the detached mindfulness and the active control group, b = 0.10 (95% CI = [-0.15, 0.34], $PP(b < 0) = 0.22$).

Negative affect. Negative affect decreased clearly stronger from t0 to t1 when the success of implementation was 1SD above the mean than when it was 1SD below the mean, across groups, b = -0.14 (95% CI = [-0.22, -0.05], $PP(b < 0) > 0.999$). Similarly, RNT decreased clearly stronger from t0 to t1 when the success of implementation was 1SD above the mean than when it was 1SD below the mean, across groups, b = -0.14 (95% CI = [-0.23, -0.05], $PP(b < 0) > 0.999$). However, the stronger decrease from t0 to t1 when the success of implementation was 1SD above the mean than when it was 1SD below the mean did not differ between the detached mindfulness and the active control group, b = 0.05 (95% CI = [-0.12, 0.22], $PP(b < 0) = 0.28$). Similarly, the stronger decrease from t0 to t2 when the success of implementation was 1SD above the mean than when it was 1SD below the mean did not differ between the detached mindfulness and the active control group, b = 0.05 (95% CI = [-0.13, 0.22], $PP(b < 0) = 0.31$).

Positive affect. Positive affect increased clearly stronger from t0 to t1 when the success of implementation was 1SD above the mean than when it was 1SD below the mean, across groups, b = 0.18 (95% CI = [0.09, 0.27], $PP(b > 0) > 0.999$). Similarly, positive affect increased clearly stronger from t0 to t1 when the success of implementation was 1SD above the mean than when it was 1SD below the mean, across groups, b = 0.14 (95% CI = [0.05, 0.23], $PP(b > 0) > 0.999$). However, the stronger increase from t0 to t1 when the success of implementation was 1SD above the mean than when it was 1SD below the mean did not differ between the detached mindfulness and the active control group, b = -0.01 (95% CI = [-0.19, 0.17], $PP(b > 0) = 0.46$). Similarly, the stronger increase from t0 to t2 when the success of implementation was 1SD above the mean than when it was 1SD below the mean did not differ between the detached mindfulness and the active control group, b = -0.03 (95% CI = [-0.22, 0.16], PP(b > 0) = 0.38).

3.9.2.3 Influence of Being in Treatment

In the beginning of the study, the pre-survey assessed whether participants were currently in psychotherapeutic and/or psychiatric treatment. At a descriptive level, there were more participants in the detached mindfulness than in the active control group that indicated that they were currently in treatment (12 vs. 5, see Table 6). Since this might confound our results, we calculated an additional analysis where we removed these subjects with parallel treatment.

3.9.2.3.1 Analyses

We reran out main analyses but only included the data of those participants who indicated that they were currently not in treatment (n = 77; n = 23 were excluded because they indicated that they were currently in psychotherapeutic and/or psychiatric treatment or did not answer this question). Specifically, we estimated a Bayesian linear multilevel model with a 3-level structure (beeps nested in days, nested in persons) for the dependent variable non-judgmental acceptance. Predictor variables were phase (baseline vs. exercise), timepoint (t0 vs. t1 vs. t2), group (active control vs. detached mindfulness), and their interactions. The factors phase and timepoint varied within persons, whereas the factor group varied between persons. Factors were effect coded. We added the factor time-window (morning vs. midday vs. evening) as a within-person predictor to model potential fluctuations of dependent variables within each day. The intercept as well as the predictors phase, timepoint, and their interaction were all added as random effects in a way that represents the maximal random structure permitted by the study design. For more details, see manuscript at section data analysis.

3.9.2.3.2 Results

Overall, the sensitivity analyses resulted in comparable estimates as our main analysis (see detailed results for all outcomes below as well as results from main analyses for comparison in bracket). Thus, our conclusions did not change when only analyzing individuals currently not in psychotherapeutic and/or psychiatric treatment.

RNT. There was a clearly stronger decrease in RNT from t0 to t1 during the exercise phase than during the baseline phase, across groups, b = -0.27 (95% CI = [-0.42, -0.11], $PP(b < 0) > 0.999$) [main analysis: b = -0.26 (95% CI = [-0.38, -0.14], $PP(b < 0) > 0.999$)]. Similarly, there was a clearly stronger decrease from t0 to t2 during the exercise phase than during the baseline phase, across groups, b = -0.26 (95% CI = [-0.41, -0.12], $PP(b < 0) > 0.999$) [main analysis: b = -0.25 (95% CI = [-0.38, -0.12], $PP(b < 0) > 0.999$)]. However, the stronger decrease from t0 to t1 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, b = 0.01 (95% CI = [-0.29, 0.26], $PP(b < 0) = 0.54$) [main analysis: b = 0.02 (95% CI = [-0.22, 0.27], $PP(b < 0) = 0.43$)]. Similarly, the stronger decrease from t0 to t2 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, b = 0.11 (95% CI = [-0.18, 0.41], $PP(b < 0) = 0.23$) [main analysis: b = 0.18 (95% CI = [-0.08, 0.44], $PP(b < 0) = 0.09$)].

Negative affect. There was a clearly stronger decrease in negative affect from t0 to t1 during the exercise phase than during the baseline phase, across groups, b = -0.14 (95% CI = [-0.23, -0.04], $PP(b < 0) > 0.999$) [main analysis: b = -0.14 (95% CI = [-0.22, -0.06], $PP(b < 0) > 0.999$)]. Similarly, there was a clearly stronger decrease from t0 to t2 during the exercise phase than during the baseline phase, across groups, b = -0.15 (95% CI = [-0.24, -0.05], $PP(b < 0) > 0.999$) [main analysis: b = -0.14 (95% CI = [-0.23, -0.05], $PP(b < 0) > 0.999$)]. However, the stronger decrease from t0 to t1 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, b = 0.01 (95% CI = [-0.20, 0.18], $PP(b < 0) = 0.53$) [main analysis: b = 0.03 (95% CI = [-0.14, 0.2], $PP(b < 0) = 0.35$)]. Similarly, the stronger decrease from t0 to t2 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, $b = 0.06$ (95% *CI* = [-0.26, 0.13], $PP(b < 0) = 0.73$) [main analysis: $b = 0.06$ (95% *CI* = [-0.12, 0.24], $PP(b < 0) = 0.26$)].

Positive affect. There was a clearly stronger increase in positive affect from t0 to t1 during the exercise phase than during the baseline phase, across groups, $b = 0.17$ (95% *CI* = [0.06, 0.28], $PP(b > 0) > 0.999$) [main analysis: $b = 0.14$ (95% *CI* = [0.05, 0.23], $PP(b > 0) > 0.999$)]. Similarly, there was a clearly stronger increase from t0 to t2 during the exercise phase than during the baseline phase, across groups, $b = 0.16$ (95% *CI* = [0.06, 0.28], $PP(b > 0) > 0.999$) [main analysis: $b = 0.14$ (95% *CI* = [0.05, 0.23], $PP(b > 0) > 0.999$)]. However, the stronger increase from t0 to t1 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, $b = -0.04$ (95% *CI* = [-0.26, 0.17], $PP(b > 0) = 0.35$) [main analysis: $b = -0.04$ (95% *CI* = [-0.22, 0.15], $PP(b > 0) = 0.35$)]. Similarly, the stronger increase from t0 to t2 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, $b = -0.06$ (95% *CI* = [-0.28, 0.16], $PP(b > 0) = 0.30$) [main analysis: $b = -0.04$ (95% *CI* = [-0.22, 0.15], $PP(b > 0) = 0.35$)].

3.9.2.4 Influence of prior experience with mindfulness or meditation

At the end of the study, we assessed participants' prior experience with meditation or mindfulness on a scale from 1 (not at all) to 7 (very much). We calculated sensitivity analyses controlling for this prior experience.

3.9.2.4.1 Analyses

We reran our main analyses but included prior experience with meditation or mindfulness as a covariate in all models. Specifically, we estimated a Bayesian linear multilevel model with a 3-level structure (beeps nested in days, nested in persons) for the dependent variable non-judgmental acceptance. Predictor variables were phase (baseline vs. exercise), timepoint (t0 vs. t1 vs. t2), group (active control vs. detached mindfulness), and their interactions. The factors phase and timepoint varied within persons, whereas the factor group varied between persons. Factors were effect coded. We added the factor time-window (morning vs. midday vs. evening) as a within-person predictor to model potential fluctuations of dependent variables within each day. Additionally, we added prior experience with mindfulness or meditation (i.e., post_mindfulness) as a level-2 predictor. The intercept as well as the predictors phase, timepoint, and their interaction were all added as random effects in a way that represents the maximal random structure permitted by the study design. For more details, see manuscript at section data analysis.

3.9.2.4.2 Results

Overall, this sensitivity analyses resulted in comparable estimates as our main analysis (see detailed results for all outcomes below as well as results from main analyses for comparison in bracket). Thus, our conclusions did not change when included prior experience as a covariate in all models.

RNT. There was a clearly stronger decrease in RNT from t0 to t1 during the exercise phase than during the baseline phase, across groups, b = -0.26 (95% CI = [-0.38, -0.14], $PP(b < 0) > 0.999$) [main analysis: b = -0.26 (95% CI = [-0.38, -0.14], $PP(b < 0) > 0.999$)]. Similarly, there was a clearly stronger decrease from t0 to t2 during the exercise phase than during the baseline phase, across groups, b = -0.25 (95% CI = [-0.38, -0.12], $PP(b < 0) > 0.999$) [main analysis: b = -0.25 (95% CI = [-0.38, -0.12], $PP(b < 0) > 0.999$)]. However, the stronger decrease from t0 to t1 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, b = 0.02 (95% CI = [-0.22, 0.27], $PP(b < 0) = 0.42$) [main analysis: b = 0.02 (95% CI = [-0.22, 0.27], $PP(b < 0) = 0.43$)]. Similarly, the stronger decrease from t0 to t2 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, b = 0.18 (95% CI = [-0.08, 0.44], $PP(b < 0)$ = 0.09) [main analysis: b = 0.18 (95% CI = [-0.08, 0.44], $PP(b < 0)$ = 0.09)].

Negative affect. There was a clearly stronger decrease in negative affect from t0 to t1 during the exercise phase than during the baseline phase, across groups, b = -0.14 (95% CI = [-0.23, -0.05], $PP(b < 0) > 0.999$) [main analysis: b = -0.14 (95% CI = [-0.22, -0.06], $PP(b < 0) > 0.999$)]. Similarly, there was a clearly stronger decrease from t0 to t2 during the exercise phase than during the baseline phase, across groups, b = -0.14 (95% CI = [-0.24, -0.05], $PP(b < 0) > 0.999$) [main analysis: b = -0.14 (95% CI = [-0.23, -0.05], $PP(b < 0) > 0.999$)]. However, the stronger decrease from t0 to t1 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, b = 0.03 (95% CI = [-0.14, 0.20], $PP(b < 0)$ = 0.55) [main analysis: b = 0.03 (95% CI = [-0.14, 0.2], $PP(b < 0)$ = 0.35)]. Similarly, the stronger decrease from t0 to t2 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, b = 0.06 (95% CI = [-0.12, 0.24], $PP(b < 0)$ = 0.27) [main analysis: b = 0.06 (95% CI = [-0.12, 0.24], $PP(b < 0)$ = 0.26)].

Positive affect. There was a clearly stronger increase in positive affect from t0 to t1 during the exercise phase than during the baseline phase, across groups, b = 0.16 (95% CI = [0.06, 0.25], $PP(b > 0) > 0.999$) [main analysis: b = 0.16 (95% CI = [0.07, 0.25], $PP(b > 0) > 0.999$)]. Similarly, there was a clearly stronger increase from t0 to t2 during the exercise phase than during the baseline phase, across groups, b = 0.14 (95% CI = [0.05, 0.23], $PP(b > 0) > 0.999$) [main analysis: b = 0.14 (95% CI = [0.05, 0.23], $PP(b > 0) > 0.999$)]. However, the stronger increase from t0 to t1 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, b = -0.04 (95% CI = [-0.22, 0.15], $PP(b > 0)$ = 0.35) [main analysis: b = -0.04 (95% CI = [-0.22, 0.15], $PP(b > 0)$ = 0.35)]. Similarly, the stronger increase from t0 to t2 during the exercise phase than during the baseline phase did not differ between the detached mindfulness and the active control group, b = -0.08 (95% CI = [-0.27, 0.11], $PP(b > 0)$ = 0.20) [main analysis: b = -0.08 (95% CI = [-0.27, 0.11], $PP(b > 0)$ = 0.25)].

3.9.3 EXPLORATORY ANALYSES

3.9.3.1 Effects on Non-Judgmental Acceptance

We examined the effects of detached mindfulness on an additional outcome variable, namely non-judgmental acceptance. Similar to the other dependent variables, we explored whether the exercise phase was associated with a stronger increase of non-judgmental acceptance from t0 to t1 and from t0 to t2 than the baseline phase. Further, we explored whether these increases were stronger in the detached mindfulness group than in the active control group.

3.9.3.1.1 Assessment and material

Non-judgmental acceptance was assessed via ESM. Participants answered to three items assessing non-judgmental acceptance after answering to the items assessing RNT, negative and positive affect. Non-judgmental acceptance was assessed with three items: "I thought some of my thoughts/feelings were slightly off.", "Things went through my mind that I should not really be engaging myself with.", and "I thought I could have acted more appropriately at a certain time." All items were derived from the respective subscale of the Multidimensional State Mindfulness Questionnaire (Blanke & Brose, 2017). In order to refer to the same time frame as for all other ESM items, we did not use the original stem "In the period since the last measurement" but "How much do these statements apply to you at the moment?" and changed the verbs from past to present tense. In our sample, the reliability of the non-judgmental acceptance scale was very good (within person: ω = 0.82 (95% CI = [0.82, 0.83]); between-person: ω = 0.92 (95% CI = [0.90, 0.95]). A total score for the scale was created by calculating the mean across all items.

3.9.3.1.2 Analysis

We calculated the same model that we used for the hypothesis testing of the other dependent variables but chose non-judgmental acceptance as dependent variable. Specifically, we estimated a Bayesian linear multilevel model with a 3-level structure (beeps nested in days, nested in persons) for the dependent variable non-judgmental acceptance. Predictor variables were phase (baseline vs. exercise), timepoint (t0 vs. t1 vs. t2), group (active control vs. detached mindfulness), and their interactions. The factors phase and timepoint varied within persons, whereas the factor group varied between persons. Factors were effect coded. We added the factor time-window (morning vs. midday vs. evening) as a within-person predictor to model potential fluctuations of dependent variables within each day. The intercept as well as the predictors phase, timepoint, and their interaction were all added as random effects in a way that represents the maximal random structure permitted by the study design. For more details, see manuscript at section data analysis.

For more information on the exact model specifications, the convergence of the models and the specific contrasts we tested, see the respective html file at https://osf.io/z2e83/ and manuscript at section Data analysis.

3.9.3.1.3 Results

There was a clearly stronger increase in non-judgmental acceptance from t0 to t1 during the exercise phase than during the baseline phase, across groups, $b = 0.20$ (95% CI = [0.1, 0.31], $PP(b > 0) > 0.999$). Similarly, there was a clearly stronger increase from t0 to t2 during the exercise phase than during the baseline phase, across groups, $b = 0.18$ (95% CI = [0.06, 0.3], $PP(b > 0) > 0.999$). However, the stronger increase from t0 to t1 in the exercise than in the baseline phase did not differ between the detached mindfulness and the active control group, $b = -0.09$ (95% CI = [-0.3, 0.13], $PP(b > 0) = 0.22$). Similarly, the stronger increase from t0 to t2 in the exercise than in the baseline phase did not differ between the detached mindfulness and the active control group, b = -0.13 (95% CI = [-0.37, 0.12], $PP(b > 0)$ = 0.15).

3.9.3.2 Day to Day Changes in Levels of RNT and Affect Before Each Exercise

We explored whether the continuous engagement in the detached mindfulness exercises showed medium-term effects on the levels of RNT and affect assessed before each exercise (base levels) over the course of the 5-day exercise phase. Accordingly, we examined whether the t0 assessments changed more strongly from day to day during the exercise phase than during the baseline phase and whether these changes were stronger in the detached mindfulness group than in the active control group.

3.9.3.2.1 Analysis

We estimated three Bayesian linear multilevel models with a 2-level structure (beeps nested in persons), one for each of the following dependent variables: RNT, negative affect, and positive affect. Predictor variables were phase (baseline vs. exercise), group (active control vs. detached mindfulness), and a new metric variable representing a counter for the days of each phase (dayphase_counter). Values could range from 1-5 (i.e., 1^{st} to 5^{th} day). We centered the variable by subtracting 3 from all its values to make the interpretation for meaningful. We also entered the interaction among all three predictors. Factors were effect coded. Lastly, we added the factor time-window (morning vs. midday vs. evening) as a within-person predictor to account for potential fluctuations of dependent variables within each day. The intercept as well as the predictors phase, dayphase_counter, and their interaction were all added as random effects in a way that represents the maximal random structure permitted by the study design.

For more information on the exact model specifications, the convergence of the models and the specific contrasts we tested, see the respective html file at https://osf.io/z2e83/.

3.9.3.2.2 Results

RNT. Base levels of RNT decreased clearly stronger from day to day during the exercise phase than during the baseline phase, across groups, b = -0.12 (95% CI = [-0.22, -0.02], $PP(b < 0) > 0.999$). However, there was no difference between the groups in these decreases, b = 0.01 (95% CI = [-0.09, 0.11], $PP(b < 0) = 0.41$).

Negative affect. Base levels of negative affect did not decrease clearly stronger from day to day during the exercise phase than during the baseline phase, across groups, b = -0.06 (95% CI = [-0.15, 0.02], $PP(b < 0) = 0.93$). There was no difference between the groups in these decreases, b = 0.04 (95% CI = [-0.05, 0.12], $PP(b < 0) = 0.41$).

Positive affect. Base levels of positive affect did not increase clearly stronger from day to day during the exercise phase than during the baseline phase, across groups, b = 0.05 (95% CI = [-0.02, 0.11], $PP(b > 0) = 0.92$). There was no difference between the groups in these increases, b = -0.01 (95% CI = [-0.08, 0.05], $PP(b > 0) = 0.35$).

3.9.3.3 Pre to Post Changes in Trait RNT and Trait Mindfulness

We explored whether there was a reduction in trait RNT (RTQ-10) and an increase in trait mindfulness (FFMQ) from the pre to the post-survey and whether these changes were stronger in the detached mindfulness group than in the active control group. The pre-survey was completed in the very beginning of the study, thus, before starting with the baseline phase. The post-survey was completed at the very end of the study, thus, after finishing the exercise phase.

3.9.3.3.1 Analysis

We estimated two Bayesian linear multilevel models with a 2-level structure (beeps nested in persons), one for each of the following dependent variables: RTQ-10 total scores and FFMQ total scores. We entered the factors time (pre- vs. post-survey), group (active control vs. detached mindfulness), and their interaction as predictors into each model. Factors were effect coded.

For more information on the exact model specifications, the convergence of the models and the specific contrasts we tested, see the respective html file at https://osf.io/z2e83/.

3.9.3.3.2 Results

Trait RNT. Trait RNT did not decrease from pre- to the post-survey, across groups, b = 0.04 (95% CI = [-1.47, 1.56], $PP(b < 0)$ = 0.49. There was no group difference in the change in trait RNT from pre- to post-survey, b = -2.96 (95% CI = [-5.91, 0.03], $PP(b < 0)$ = 0.97.

Trait mindfulness. Trait mindfulness did not clearly increase from the pre- to the post-survey, across groups, b = 1.57 (95% CI = [-0.95, 4.14], $PP(b > 0)$ = 0.89. However, the detached mindfulness group had a clearly stronger increase in trait mindfulness from pre- to post-survey as compared to the active control group, b = 6.59 (95% CI = [1.54, 11.62], $PP(b > 0) > 0.99$.

CHAPTER 4:

DISCUSSION

4.1 SUMMARY OF FINDINGS

This dissertation aimed to determine whether engaging in brief mindfulness interventions in daily life leads to immediate benefits for RNT and affect. Two RCTs were conducted to answer this question. In both studies, participants completed audio-guided mindfulness interventions multiple times per day over several days. Immediately after each intervention, participants reported their RNT and affect via ESM.

In STUDY 1, participants were randomized at each assessment to complete either the mindfulness intervention or an active control task consisting of listening to neutral background sounds, over 10 days. Results showed that participants reported less RNT and less negative affect after completing the mindfulness intervention as compared to the control task. However, the dynamic relationship between RNT and negative affect was not impacted by the mindfulness intervention. Thus, how much RNT and negative affect persisted over time and how strongly they were associated with each other was not moderated by the mindfulness intervention.

In STUDY 2, participants completed either a brief mindfulness intervention or an active control task that was designed to match the mindfulness intervention except for the mindfulness instructions, over 5 days. Participants were randomized to the detached mindfulness or the active control group. Before this intervention phase, all participants completed a 5-day baseline phase without any intervention, consisting only of ESM assessments. Results showed that participants of both groups reported stronger reductions in RNT, stronger reductions in negative affect, and stronger improvements in positive affect during the intervention phase compared to the baseline phase. Thus, participants improved more when completing the tasks as compared to not completing them. However, there were no differences between the groups. Thus, the mindfulness intervention and the active control task were equally effective.

4.2 INTEGRATION AND INTERPRETATION OF FINDINGS

The central question of this dissertation is whether brief mindfulness interventions lead to immediate benefits for RNT and affect in daily life. What is the answer to this question when linking the findings of both studies[5]?

The results of this dissertation indicate that finding an effect of the mindfulness interventions depended on the control conditions used as a comparison. Our mindfulness interventions consisted of verbally guided audio tasks that instructed participants step-by-step to engage in mindfulness. These interventions were compared to various control conditions: (i) a passive control condition (STUDY 2), (ii) an active control condition consisting of an audio track with neutral background sounds for participants to listen to (STUDY 1), and (iii) an active control condition intended to match the mindfulness intervention in every aspect except for the mindfulness instructions and which resembled a guided imagery exercise (STUDY 2). We observed stronger improvements after the mindfulness intervention compared to the passive control condition in STUDY 2. Yet, the active control task of STUDY 2 was *equally* effective as the mindfulness intervention. In contrast, the mindfulness intervention of STUDY 1 was *more* effective than the active control condition. To explain these results, we need to examine the characteristics of the mindfulness interventions and the control conditions. Specifically, given that the mindfulness intervention in STUDY 1 was superior to its active control condition, while the mindfulness intervention and the control task in STUDY 2 were equally effective, we must identify the characteristics that these tasks shared and simultaneously distinguished them from the less effective control conditions. In other words, we need to reflect upon potential mechanisms of action which led to less RNT and better affect. Different mechanisms could have been at play.

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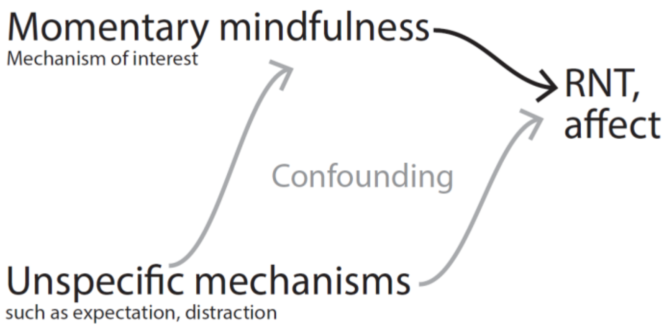
[5] This general discussion focuses on the effects of the mindfulness interventions on *levels* of RNT and affect, as these were outcomes in both studies. STUDY 1 also investigated the effect on the dynamic relationship between RNT and affect, which is discussed separately in the discussion section of STUDY 1.

Momentary mindfulness. Mindfulness interventions intend to increase momentary mindfulness which is in turn assumed to be beneficial for RNT and affect. Thus, the first assumption should be that experiencing momentary mindfulness is the mechanism inducing superiority. We assessed momentary mindfulness after each intervention in both studies. In STUDY 1, momentary mindfulness was higher after the mindfulness intervention compared to the active control task, indicating that the manipulation was successful. Thus, we could assume that momentary mindfulness is the mechanism here. However, this cannot be clearly determined because the mindfulness intervention differed from the active control task in several unspecific factors. Unspecific factors are those that may lead to improvements but are unrelated to mindfulness (see below for a detailed discussion of plausible mindfulness-unspecific factors). Without controlling for these unspecific factors, we cannot rule out that they are the mechanisms responsible for better RNT and affect. This issue is particularly relevant for the comparison to the passive control condition in STUDY 2, which only controlled for the passage of time and did not address other potential mindfulness-unspecific mechanisms. Therefore, although we observed less RNT and negative affect after the mindfulness intervention along with higher momentary mindfulness in STUDY 1, another mechanism could have been (partly) responsible for these benefits. This other mechanism might have confounded the relationship between momentary mindfulness and RNT/affect, meaning it could have caused both higher momentary mindfulness and less RNT/negative affect, rather than momentary mindfulness being the cause for less RNT/negative affect (see Figure 8). Thus, while the findings of STUDY 1 suggest that momentary mindfulness could be the mechanism, we cannot confirm this with certainty. A more definitive conclusion would have required that the control task accounts for mindfulness-unspecific factors.

Figure 8

Potential Confounding



Note. Momentary mindfulness may have caused less RNT and negative affect. However, it is also possible that mindfulness-unspecific mechanisms, such as expectation and distraction, caused less RNT and negative affect, and higher momentary mindfulness. In that case, mindfulness-unspecific mechanisms would have confounded the relationship between momentary mindfulness and RNT/affect. Such confounding cannot be ruled out because the control task of STUDY 1 did not account for these factors.

In STUDY 2, unexpectedly, the mindfulness intervention did not increase momentary mindfulness more than the active control task. Thus, our manipulation was unsuccessful in enhancing momentary mindfulness more strongly through the mindfulness intervention (see Chapter 4.4 for a discussion on potential reasons for this unsuccessful manipulation). This suggests that including or excluding the detached mindfulness instructions in the tasks made no difference because momentary mindfulness as well as RNT and affect improved equally well through both tasks. Yet, it is still possible that momentary mindfulness *was* the mechanism because both the mindfulness intervention and the control task improved RNT and affect equally well. This assumption is supported by the negative correlation (r = -0.43) between changes in momentary mindfulness and changes in RNT[6]. In other words, increases in momentary mindfulness were associated with decreases in RNT. However, as momentary mindfulness was not higher in the mindfulness intervention we cannot conclusively

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[6] We calculated the correlation between the residuals of RNT and momentary mindfulness. Specifically, two multi-level models were calculated in which RNT and momentary mindfulness 15 minutes after the intervention (t1) were each predicted by their respective levels before the intervention (t0). Then, the correlation between the residuals of these models was calculated.

determine whether momentary mindfulness was the mechanism. Instead, mindfulness-unspecific factors that both tasks shared might have been (partly) responsible. These other mechanisms, again, could have acted as confounding variables, leading to higher momentary mindfulness and improved RNT/affect (compare Figure 8) In sum, findings from STUDY 1 and STUDY 2 suggest that momentary mindfulness could have been the mechanism leading to superior outcomes in RNT and affect. However, we cannot determine this conclusively. In STUDY 1, we cannot be certain because the control task did not account for mindfulness-unspecific mechanisms. In STUDY 2, we cannot be certain because momentary mindfulness improved equally in both the control and mindfulness groups, and therefore other shared characteristics of the tasks could be the mechanisms. We could have drawn more definitive conclusions about mindfulness as a specific mechanism if we had successfully manipulated momentary mindfulness in STUDY 2. I propose a study design that would allow clearer conclusions about mindfulness as a mechanism in Chapter 4.4.

If momentary mindfulness was not the mechanism responsible for better RNT and affect in both studies, what could have been other mechanisms? Several are possible. I discuss two plausible factors: expectation of benefit and distraction through guidance during the exercises.

Expectations. Positive expectations towards the helpfulness of the tasks might have driven better outcomes. In STUDY 2, we compared the mindfulness intervention to a control task that was closely matched, except for the detached mindfulness instructions. This matching also included efforts to induce the same expectations across both groups by informing participants that their task might be helpful in dealing with negative thoughts. In contrast, STUDY 1 did not explicitly aim to equalize expectation effects between the conditions. Participants knew that the study's aim was to investigate the effects of mindfulness. A recent study of brief mindfulness interventions showed that such labeling of interventions with mindfulness can already induce expectation effects

(Ghanbari Noshari et al., 2023). Additionally, participants of STUDY 1 engaged in both the mindfulness intervention and the control task, allowing for direct comparison. No information was provided concerning the active control task and it is likely that listening to neutral background sounds did not elicit positive expectations. Consequently, participants in STUDY 1 are likely to have had higher expectations about the mindfulness intervention compared to the active control task.

Expectation effects are crucial to control because “only when the active control group has the same expectation of improvement as the experimental group can we attribute differential improvements to the potency of the treatment.” (Boot et al., 2013, p. 445). In other words, only if we control for expectation effects, we can rule out that expectation is actually the mechanism responsible for improvements. A recent experimental study also highlights the impact of expectations on RNT. Participants received a mock treatment (a nasal spray) and were told it would be beneficial for their rumination (Rebstock et al., 2020). The study found that this principally ineffective but believed-to-be-helpful intervention led to benefits for RNT and negative affect, underscoring the necessity to account for expectations.

In sum, positive expectations might have been the mechanism leading to superior outcomes for the mindfulness intervention in STUDY 1 and the equal effects for the mindfulness intervention and the active control task in STUDY 2.

Distraction. Distraction from current experiences through the verbal guidance provided in the tasks is another plausible mechanism leading to less RNT and better affect[7]. The mindfulness interventions of both studies consisted of audio tracks that verbally guided participants step-by-step to approach their experiences non-judgmentally. In STUDY 2, the control task was matched to the mindfulness

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[7] Guidance can also refer to the *support* provided during a task. Guidance is likely to increase the effectiveness of a task because individuals are more likely to perform it correctly because of the support. This may also apply to our tasks, meaning that the guidance in our studies may have facilitated participants to correctly engage in the tasks. In this section, however, I discuss guidance in the context of the distraction it may have induced.

intervention except for the mindfulness instructions, meaning it encompassed the same degree of verbal guidance. In contrast, the active control task in STUDY 1 involved listening to an audio track with neutral background sounds. This track was matched in duration and sound profile (e.g., number of silences), but included no guidance. Participants' minds may have been more "left on their own" without verbal guidance, potentially letting participants switch back to their ruminative thoughts. In contrast, verbal guidance may have kept participants focused on the task. This might have distracted them from unpleasant thoughts and feelings.

Previous research has shown that distraction can be beneficial in the short term. For example, distraction has been shown to reduce unpleasant experiences, especially when used in place of rumination (Denson et al., 2012; Huffziger & Kuehner, 2009; Nolen-Hoeksema et al., 2008). Additionally, a meta-analysis of lab studies revealed that distraction was equally effective as brief mindfulness interventions in reducing RNT (Leyland et al., 2019).

In sum, verbal guidance in the mindfulness interventions and in the control task of STUDY 2 may have induced distraction effects, possibly explaining their superiority compared to the unguided control tasks.

Taken together, experiencing momentary mindfulness, being distracted by verbal guidance, and expecting benefits from a task could have been mechanisms contributing to less RNT and better affect. These characteristics were shared among the mindfulness intervention of STUDY 1, the mindfulness intervention of STUDY 2, and the control task of STUDY 2, and, additionally, these were characteristics that distinguished them from the control conditions that they were superior to. Framed differently, the mindfulness interventions of both studies and the control task of STUDY 2 included more potential mechanisms and thereby might have become more "active" as compared to the control conditions that they were superior to (i.e., compared to no intervention in the passive control condition of STUDY 2 and compared to listening to neutral background sounds in the active control condition of STUDY 1). Metanalyses indicate that the effects of mindfulness interventions are biggest when the control condition is passive; effects are smaller and less often significant when the control condition is active and, thus, may include more potential mechanisms (see Galante et al., 2021 for a meta-analysis of mindfulness programs in non-clinical settings; see Goldberg, 2022 for a meta-analysis of MBI programs; see Schumer et al., 2018 for a meta-analysis of mindfulness interventions lasting less than two weeks). This matches the results of the studies included in this dissertation.

Now, having discussed the findings of the studies in light of the characteristics of mindfulness interventions and control tasks, and potential mechanisms responsible for less RNT and better affect, what can we conclude? Do brief mindfulness interventions have an immediate impact on RNT and affect in daily life?

Findings indicate that it is beneficial to engage in a task that is verbally guided and that is likely to have elicited positive expectations towards the task. However, which mechanisms led to less RNT and better affect cannot be conclusively determined. It could be experiencing momentary mindfulness. If that were the case, mindfulness interventions that successfully increase momentary mindfulness can be deemed helpful. Yet, our findings suggest that other mechanisms may also be responsible for immediate benefits. For example, it may be that distracting participants from current thoughts and feelings by closely guiding them through an exercise led to the benefits. If that were the case, mindfulness interventions increasing momentary mindfulness may not be necessary for immediate improvements in RNT and affect but rather interventions that closely guide participants to effectively distract them from their thoughts and feelings.

4.3 STRENGTHS

The studies of this dissertation have several strengths. A major strength lies in testing the effects of mindfulness interventions through RCTs in a daily life context. This has multiple benefits. First, interventions are tested in a naturalistic environment. Previous studies have shown that brief mindfulness interventions can be beneficial in laboratory settings (Leyland et al., 2019). However, the value of such interventions is amplified when their efficacy is demonstrated in real-world settings, not just controlled environments. Therefore, it is a strength that this dissertation provides an ecologically valid understanding of the impact of mindfulness interventions.

Second, we tested the causal effects of mindfulness in daily life. Several previous studies have explored the relationship between momentary mindfulness and RNT, or affect in daily life (e.g., Blanke et al., 2020). However, these studies forbid causal conclusions due to their observational nature, which is susceptible to confounding variables. This dissertation addresses this limitation by randomizing participants to complete either the mindfulness intervention or the control task. This allows us to attribute observed effects causally to the conditions in naturalistic settings.

Third, we used ESM to assess the immediate effects of the interventions. ESM has several advantages (Csikszentmihalyi & Larson, 1987; Myin-Germeys & Kuppens, 2022). It reduces memory bias compared to retrospective self-assessments by capturing experiences in the moment. Moreover, the ecological validity of ESM data is high because of assessments in the natural environment. Additionally, repeated assessments throughout the day over multiple days improve data reliability compared to single-time assessments typical in intervention studies. Lastly, ESM allows investigation into the dynamic relationships between experiences over time. This enabled us to assess not only the impact of the intervention on levels of RNT and affect but also on the dynamic relations of these constructs (i.e., the spiral of negativity that these variables tend to establish; see Chapter 2 for a discussion of results concerning the dynamic relations in STUDY 1).

The second major strength of the studies in this dissertation is the implementation of different control conditions which allowed us to look at the effectiveness of mindfulness from different angles and under consideration of various potential mechanisms of action. Mindfulness was compared to three control comparisons in this dissertation – one passive, and two active ones. Studies testing the effects of mindfulness interventions often compare it to passive control conditions only. However, this does not provide clear insights into whether mindfulness itself is beneficial or if improvements are due to other characteristics of the tasks. Our condition task of STUDY 2 is especially valuable because we intended to control for various mindfulness-unspecific mechanisms. Such a matched and strongly controlled comparison condition is seldom. Surprisingly, momentary mindfulness was equally increased in the mindfulness and active control groups which restricts to clearly state whether experiencing momentary mindfulness was the effective component or other characteristics that both tasks shared (see discussion in Chapter 4.2). Still, if we *had* observed more momentary mindfulness after the mindfulness intervention, our study design would have allowed to more strongly attribute benefits to momentary mindfulness in comparison to studies using less well-designed control conditions.

Another strength is the chosen sample criteria. RNT is a transdiagnostic risk factor for psychopathology. Consequently, reducing RNT through mindfulness could serve as a prevention strategy for psychopathology. This dissertation investigated mindfulness interventions in a healthy sample and in individuals with elevated trait RNT. This dual focus is crucial for understanding whether mindfulness can effectively reduce RNT in non-clinical populations and in populations with elevated trait RNT as a risk factor for psychopathology.

Finally, the studies in this dissertation implemented a range of open science practices. These practices included pre-registering studies, publishing pre-prints, making study materials openly accessible, and sharing data and code publicly. Hereby, we aimed to contribute to an open, transparent, reproducible, and replicable research process. Additionally, these practices serve the scientific community by providing resources for further research.

4.4 LIMITATIONS AND FUTURE STUDIES

The findings of this dissertation must be interpreted in light of several limitations that could be addressed in future studies.

Our findings apply to brief, verbally guided mindfulness interventions whose effects were assessed immediately after each intervention. Other effects might be observed for longer interventions (e.g., 15 minutes per practice), verbally unguided mindfulness interventions (e.g., written instructions), and when effects are assessed less immediately (e.g., after 1 hour). A meta-analysis of mindfulness interventions lasting less than two weeks showed that the more immediate outcomes were assessed, the stronger the effects (Schumer et al., 2018). This suggests that the effects of brief interventions may fade away quickly. Therefore, it is reasonable to expect that replication studies with a less immediate outcome assessment of each intervention would observe smaller effects.

Moreover, the generalizability of findings may be limited by the characteristics of the sample. Our sample primarily comprised white and higher educated participants. Findings may not generalize to non-WEIRD (western, educated, industrialized, rich, and democratic) populations where effects can differ (see Ng & Ong, 2022 for cases where intervention effects vary across cultures; see Sun et al., 2022 for a meta-analysis showing that the effects of MBIs are smaller among people of color). Additionally, we investigated the effects of mindfulness interventions in a healthy sample and in a sample with elevated trait RNT. Clinical samples might show different effects, as previous research suggests that mindfulness effects may be stronger in clinical populations (Schumer et al., 2018). One possible explanation is that higher symptom levels in clinical populations provide more "room for improvement" (Mao et al., 2023, p.

84). It also remains unknown whether the same effects would be observed in representative samples. Our participants self-selected into the study, likely indicating some level of motivation to participate. This may have distorted effects.

Another limitation is the lack of expectation measurement. While we aimed to induce similar expectations for both the mindfulness intervention and the control task in STUDY 2, we did not assess participants' expectations. Future studies could assess participants' expectations to validate whether the manipulation was successful and to investigate expectation as a potential mechanism.

A challenge in investigating mindfulness interventions is the uncertainty regarding what participants actually do during mindfulness practices (Van Dam et al., 2018). What mindfulness is and how it is applied can be hard to grasp. Therefore, we assume in our studies that participants engage in mindfulness in a certain way, while they might be doing something different. Future studies could include introductory sessions explaining the concepts of mindfulness and allowing participants to practice under supervision. Such sessions would help ensure that participants have a similar understanding and application of mindfulness.

Finally, it is a limitation that our manipulation was not successful in STUDY 2. Thus, our mindfulness intervention did not increase momentary mindfulness more than the control task. This restricted the conclusion we can draw about momentary mindfulness being the mechanism. Two reasons could explain why both tasks increased momentary mindfulness similarly. First, participants may have struggled to implement the detached mindfulness exercises as intended because they were too challenging without a more in-depth introduction to the concept. This would indicate that future studies should modify this instruction or, again, provide an introductory session. Second, given the equal increase in momentary mindfulness across the two tasks, it is more likely that the control task induced more mindfulness than intended. Our active control task in STUDY 2 asked participants to imagine various elements in their imagined surroundings. For example, they were instructed to imagine clouds in the sky, then birds, then a bee. The control task can therefore be described as a guided imagery exercise. It is possible that this control task became a form of mindfulness intervention itself. Mindfulness involves two key components: 1) attending to and observing the present moment, and 2) doing so with a certain attitude such as non-judgment (compare Chapter 1.2.1; Lindsay & Creswell, 2017). Our control task might have included the first mindfulness component because participants' attention was directed to different elements in their imagined surroundings and the task encompassed to notice and observe these elements. This would indicate that our active control instruction is not suitable as a control task that was understood as being mindfulness-unrelated. Regardless of why the manipulation did not work, the unsuccessful manipulation restricts the conclusion we can draw about mindfulness being the mechanism as other factors that were equal across the groups may have been responsible for less RNT and better affect.

To gain solid evidence about whether momentary mindfulness is the helpful mechanism, I propose that future studies should: 1) include a mindfulness intervention that increases momentary mindfulness, 2) compare this to a control task that does not (or at least less so than the mindfulness intervention) increase mindfulness but that accounts for mindfulness-unspecific mechanisms such as distraction. Such future studies should collect data as well as apply analyses in such a way that it is possible to determine whether improvements in RNT and affect are *temporally mediated* by increased momentary mindfulness. In other words, the mindfulness intervention should reliably increase momentary mindfulness, and it should be investigated whether this momentary mindfulness precedes improvements in RNT and affect. If such a study finds differences between the conditions, this would provide stronger evidence for mindfulness being a beneficial mechanism in improving RNT and affect.

4.5 CLINICAL IMPLICATIONS

The findings of the included studies do not allow us to conclusively determine which is the responsible mechanism leading to less RNT and better affect. Clinical implications can therefore be discussed considering these different possible mechanisms. While it is unlikely that only one mechanism was involved, I discuss each potential mechanism separately for clarity.

If distraction through guidance was the responsible mechanism, this implies that engaging in tasks that direct individuals' attention away from how they typically think and feel (i.e., without an intervention; their default mode of processing) might be sufficient to improve their RNT and affect. Hence, individuals suffering from intense RNT may simply engage in tasks that continuously instruct them to direct their attention to certain elements in their surroundings. This may already help to alleviate RNT and improve affect. However, it has to be kept in mind that this applies to the immediate effects and permanent distraction may not be beneficial in the long-term.

If positive expectation about the tasks was the responsible mechanism, this suggests that informing participants that the task they will engage in will be helpful might be enough to produce benefits. This would imply that any intervention aiming to improve RNT and affect can benefit from adding information such as "This task will help you better deal with rumination and worries." However, ethical considerations forbid irresponsibly adding such statements to interventions, especially to potentially detrimental ones. If interventions intend to rely on placebo effects this needs to be done as open-label placebos which administer placebos under full transparency and thereby under ethical considerations (Buergler et al., 2023).

If indeed momentary mindfulness is the mechanism inducing immediate benefits for RNT and affect, then it is not enough to distract and inform individuals that they will benefit. Rather, individuals need to enter a state where they become aware of ongoing thoughts and feelings and approach them in a non-judgmental manner.

Interventions in clinical practice would then need to successfully increase momentary mindfulness to achieve benefits. Our findings indicate that such a state of momentary mindfulness may not only be reached with explicit mindfulness interventions but also by tasks such as our active control task in STUDY 2, which can be understood as a guided imagery exercise (potentially including some mindfulness components as discussed in Chapter 4.4). However, this may only apply to our specific detached mindfulness instruction and may not be generalizable to other mindfulness instructions. For example, a detached mindfulness instruction without any imagination may be more helpful for certain individuals. Some participants reported in the qualitative feedback assessed at the end of STUDY 2 that they had difficulties with the imaginary part of our intervention. For instance, they struggled to imagine clouds in the sky and to then picture these clouds as their thoughts. These individuals might prefer and benefit more from mindfulness instructions that do not involve imagery.

The non-difference in momentary mindfulness in STUDY 2 suggests that if the goal is to increase momentary mindfulness more effectively than the control, alternative instructions or mindfulness tasks are necessary. The concepts of mindfulness can be complex, and it might be challenging for some individuals to understand and especially implement ideas such as "thoughts are just thoughts" and “stepping back from thoughts to observe them”. Therefore, it may be beneficial to incorporate introductory sessions where the concepts of mindfulness are thoroughly explained and individuals engage in initial practice under supervision. Such sessions would ensure that individuals understand and perform the exercises correctly. These sessions could also be used to prevent the frustration that may arise towards the mindfulness intervention: Informing participants that a goal of mindfulness is to observe without judgment may create pressure because non-judgment is difficult and failing at reaching it is therefore likely. A potential solution is to explain that non-judgment is only the ideal that can be used as a guiding principle but that will rarely be reached fully.

Although we could not conclusively determine the mechanism of change, our findings show that RNT and affect can be improved by engaging in brief audio-guided tasks in daily life. Given that RNT is a risk factor for and a prevalent symptom in psychopathology, this suggests that these tasks could function as a preventive strategy or be applied in clinical practice to lower symptoms. These tasks cannot and should not replace therapy. However, it is conceivable that they could be used as an add-on to psychotherapy. Once introduced by the clinician, these tasks could be completed independently by the patient between therapy sessions, thereby providing additional support on the path to improvement. From an ethical point of view, it is necessary, however, to clarify that the actual mechanism of action of the interventions is still unclear and that previously observed benefits apply to RNT and affect assessed immediately after the interventions.

4.6 CONCLUSION

This dissertation set out to investigate the immediate impact of brief mindfulness interventions on RNT and affect in daily life. In other words, this dissertation asked whether engaging in brief mindfulness interventions in daily life can help individuals think and feel in a more beneficial way immediately. The findings of this dissertation allow for two types of conclusions. First, conclusions about the effectiveness of the interventions, and second, conclusions about the mechanisms leading to improvements.

Effectiveness. The results of this dissertation suggest that detecting an effect of mindfulness interventions depends on the control condition used as a comparison. Participants reported less RNT and better affect after completing the guided mindfulness interventions compared to both (1) not engaging in any task and (2) listening to neutral background sounds. This suggests that engaging in brief mindfulness interventions can improve individuals' RNT and affect as compared to continuing with how they would think and feel without the intervention (i.e., their default mode of processing), and compared to engaging in an unguided task. However, the mindfulness intervention was equally effective as a matched control task without mindfulness instructions (i.e., guided imagery). Thus, engaging in a task that corresponds to a guided imagery exercise seems equally helpful for immediate improvements.

Mechanisms. The studies in this dissertation do not allow us to conclusively determine which mechanisms led to the superiority across both mindfulness intervention and the guided imagery task. It could be momentary mindfulness. If that were the case, it would be helpful for individuals' RNT and affect if they enter a state in which they attend to the present moment non-judgmentally. And consequently, intervention should aim at increasing momentary mindfulness. However, mindfulness-unspecific mechanisms, such as expectations towards helpfulness of the tasks or distraction, may also have caused the benefits. If that were the case, it may be enough that individuals direct their attention away from current RNT for immediate reductions of RNT and unpleasant affect.

Overall, we can conclude that brief guided mindfulness interventions and guided imagery tasks appear helpful to immediately reduce RNT and improve affect in daily life. Thus, these tasks seem beneficial for individuals to disentangle from their RNT and feel better immediately. Whether these tasks lead to benefits by increasing momentary mindfulness or via other mechanisms remains to be elucidated. It would be valuable to build on the findings of this dissertation and continue investigating the underlying mechanisms because RNT is highly relevant to how we feel in daily life, and because it is a transdiagnostic symptom and risk factor for psychopathology. By understanding the mechanisms that reduce RNT, we can develop the most precise and effective interventions for RNT and thereby reduce symptoms and ideally prevent psychopathology.

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APPENDIX

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LIST OF ABBREVIATIONS

DSEM	Dynamic structural equation modeling
ESM	Experience sampling methodology
GAD	Generalized anxiety disorder
H	Hypothesis
Lab	Laboratory
MBCT	Mindfulness-based cognitive therapy
MBSR	Mindfulness-based stress reduction
MI	Mindfulness intervention
MF	Momentary/state mindfulness
MMEE	Momentary Mindfulness and Everyday Emotion
NA	Negative affect
RCT	Randomized controlled trial
RNT	Repetitive negative thinking
SAD	Social anxiety disorder

GERMAN SUMMARY

Repetitives negatives Denken (RNT) ist ein problematischer Denkstil, der Grübeln und Sorgen umfasst. RNT ist dadurch gekennzeichnet, dass sich die Gedanken wiederholt um negative Inhalte, wie beispielsweise Probleme oder unangenehme Erlebnisse, drehen. RNT ist mit negativem Affekt und verschiedenen psychopathologischen Symptomen assoziiert und sagt sogar die Neuentstehung dieser Symptome voraus, was RNT als transdiagnostischen Risikofaktor für Psychopathologie kennzeichnet. Dies macht RNT zu einem idealen Kandidaten für Interventionen, da seine Verringerung dazu beitragen kann, eine Verschlechterung von Affekt und Symptomen zu vermeiden und möglicher Weise sogar Psychopathologie zu verhindern.

Achtsamkeitsinterventionen sind vielversprechend, um RNT zu reduzieren, denn Achtsamkeit lehrt, sich Empfindungen, Gefühle und Gedanken bewusst zu machen und diesen beobachtend sowie nicht wertend zu begegnen, anstatt in Negativität zu verharren. Bisherige Forschungsergebnisse deuten darauf hin, dass Achtsamkeitsinterventionen tatsächlich hilfreich sein können, um RNT und Symptome zu verringern und den Affekt zu verbessern. Es bleibt jedoch weitgehend unbeantwortet, ob kurze Achtsamkeitsinterventionen, die im täglichen Leben durchgeführt werden, zu einer unmittelbaren Verbesserung im RNT und Affekt führt. Im Rahmen dieser Dissertation wurden zwei randomisierte kontrollierte Studien durchgeführt, um diese Frage zu beantworten. In beiden Studien absolvierten die Teilnehmenden über mehrere Tage hinweg mehrmals täglich kurze audiogeführte Achtsamkeitsinterventionen. Unmittelbar nach jeder Intervention berichteten die Teilnehmer ihr RNT und ihren Affekt mittels der Experience Sampling Methode (ESM).

STUDY 1 untersuchte die Auswirkungen einer Achtsamkeitsintervention bei N = 91 nicht-klinischen Teilnehmenden. Über einen Zeitraum von 10 Tagen wurden die Teilnehmenden bei jeder Erhebung randomisiert, entweder zu einer Achtsamkeitsintervention oder zu einer aktive Kontrollaufgabe, die aus dem Anhören

neutraler Hintergrundgeräusche bestand. Die Ergebnisse von STUDY 1 zeigten, dass die Teilnehmenden nach Durchführung der Achtsamkeitsintervention im Vergleich zur Kontrollbedingung weniger RNT und weniger negativen Affekt berichteten. Die Assoziationen zwischen RNT und negativem Affekt wurden durch die Achtsamkeitsintervention jedoch nicht beeinflusst.

STUDY 2 untersuchte die Auswirkungen einer losgelösten Achtsamkeitsintervention bei N = 100 Teilnehmenden mit erhöhtem trait RNT. Die Studie bestand aus einer 5-tägigen Baselinephase, in der nur ESM-Erhebungen durchgeführt wurden und einer 5-tägigen Interventionsphase, in der die Teilnehmenden zusätzlich entweder eine losgelöste Achtsamkeitsintervention oder eine aktive Kontrollaufgabe absolvierten, je nachdem, zu welcher Gruppe sie randomisiert wurden. Die Kontrollaufgabe ähnelte der Achtsamkeitsintervention, außer dass die Achtsamkeitsinstruktionen entfernt wurden; die Kontrollaufgabe entsprach einer geführten Imagination. Die Ergebnisse von STUDY 2 zeigten, dass die Teilnehmenden beider Gruppen während der Interventionsphase eine stärkere Verringerung des RNTs und des negativen Affekts sowie einen stärkeren Anstieg des positiven Affekts berichteten als in der Baselinephase ohne Intervention. Es gab jedoch keine Unterschiede zwischen den Gruppen.

Die Integration der Studienergebnisse erlaubt es, Schlussfolgerungen über die Effektivität von Achtsamkeitsinterventionen und über die Wirkmechanismen zu ziehen.

Effektivität. Die Ergebnisse deuten darauf hin, dass das Nachweisen von Effektivität der Achtsamkeitsinterventionen davon abhing, welche Kontrollbedingung verwendet wurde. Unsere geführten Achtsamkeitsinterventionen führten zu weniger RNT und negativem Affekt (i) im Vergleich zu wenn keine Übung durchführt wurde (STUDY 2) und (ii) im Vergleich zum Anhören neutraler Hintergrundgeräusche (STUDY 1). Die Achtsamkeitsintervention war jedoch ebenso wirksam wie eine Kontrollaufgabe, die der Achtsamkeitsintervention entsprach, allerdings keine Achtsamkeitsinstruktionen enthielt (geführte Imagination; STUDY 2).

Mechanismen. Die Studien dieser Dissertation erlauben es nicht, abschließend zu bestimmen, welche Mechanismen den Nutzen erzeugt haben, der bei beiden Achtsamkeitsinterventionen und bei der geführten Imagination beobachtet wurde. Es ist möglich, dass das Erleben von momentaner Achtsamkeit zu verringertem RNT und einem besseren Affekt führte. Allerdings könnten auch achtsamkeits-unspezifische Mechanismen, wie z.B. Erwartungen an die Nützlichkeit der Aufgabe oder Ablenkung von momentanem RNT und Affekt, (teilweise) für den beobachteten Nutzen verantwortlich gewesen sein.

Insgesamt deuten die Ergebnisse dieser Dissertation darauf hin, dass kurze geführte Achtsamkeitsinterventionen und geführte Imaginationen hilfreich sind, um RNT unmittelbar zu reduzieren und den Affekt im Alltag zu verbessern. Ob diese Aufgaben durch die Steigerung von momentaner Achtsamkeit oder über andere Mechanismen einen Nutzen bewirken, bleibt herauszufinden.

LIST OF INCLUDED STUDIES

STUDY 1

This manuscript was submitted at *Affective Science.*

Bolzenkötter, T., Neubauer, A., B. Koval, P. (2024). Impact of a Momentary Mindfulness Intervention on Rumination, Negative Affect, and their Dynamics in Daily Life. [Manuscript submitted for publication]

STUDY 2

This paper was published in *Mindfulness*.

Bolzenkötter, T., Bürkner, P.-C., Zetsche, U., & Schulze, L. (2024). Assessing the immediate effects of detached mindfulness on repetitive negative thinking and affect in daily life: A randomized controlled trial. *Mindfulness, 15*, 1136–1148. https://doi.org/10.1007/s12671-024-02350-5

CURRICULUM VITAE

The curriculum vitae is not included in the online version for privacy reasons.

PUBLICATIONS

Bolzenkötter, T., Bürkner, P. C., Zetsche, U., & Schulze, L. (2024). Assessing the Immediate Effects of Detached Mindfulness on Repetitive Negative Thinking and Affect in Daily Life: A Randomized Controlled Trial. *Mindfulness*, 1-13. https://doi.org/10.1007/s12671-024-02350-5

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CONFERENCE PRESENTATIONS (selection)

Bolzenkötter, T., Neubauer, A.B., & Koval, P. (2024, June 14). *Wie beeinflussen kurze Achtsamkeits-Interventionen Rumination, negativen Affekt und ihre dynamischen Verbindungen im Alltag?* [Paper presentation]. Deutscher Psychotherapie Kongress, Berlin, Germany.

Bolzenkötter, T., Bürkner, P.-C., Zetsche, U. & Schulze, L. (2024, June 13). *Die unmittelbaren Auswirkungen von losgelöster Achtsamkeit auf repetitives negatives Denken und Affekt im Alltag – eine randomisierte kontrollierte Studie* [Paper presentation]. Deutscher Psychotherapie Kongress, Berlin, Germany.

Bolzenkötter, T., Neubauer, A.B., & Koval, P. (2024, February 10). *A daily life experiment investigating the causal effect of momentary mindfulness on rumination, negative affect, and their dynamic interplay* [poster presentation]. Society for Personality and Social Psychology annual convention, San Diego, USA.

Bolzenkötter, T., Neubauer, A.B., & Koval, P. (2023, October 4). *Does a momentary mindfulness intervention impact rumination, negative affect, and their dynamics* [Paper presentation]. Emotions, Utrecht, Netherlands.

Bolzenkötter, T., Zetsche, U., Bürkner, P., Renneberg, B., & Schulze, L (2022, September 9). *Assessing the short-term effects of detached mindfulness: A micro-intervention for repetitive negative thinking* [Paper presentation]. Conference of the European Association of Behavioural and Cognitive Therapies, Barcelona, Spain.

Bolzenkötter, T., Zetsche, U., Renneberg, B., & Schulze, L (2021, June 19). *Assessing the short-term effects of detached mindfulness: A micro-intervention for repetitive negative thinking* [Pre data Poster presentation]. Conference of the Society for the Improvement of Psychological Sciences, online.

SELBSTSTÄNDIGKEITSERKLÄRUNG

Hiermit erkläre ich, die vorliegende Dissertation selbstständig verfasst und ohne unerlaubte Hilfe angefertigt habe; dass ich die Stellen der Arbeit, die dem Wortlaut oder dem Sinn nach anderen Werken (dazu zählen auch Internetquellen und KI-basierte Tools) entnommen sind, unter Angabe der Quelle kenntlich gemacht habe; dass ich alle Hilfsmittel, die verwendet wurden, angegeben habe; dass die Dissertation in keinem früheren Promotionsverfahren angenommen oder abgelehnt worden.

Berlin, August 2024

Teresa Bolzenkötter