The decentering component of mindfulness reduces reactions to mental imagery

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Abstract

Four experiments examined whether reactions to mental imagery can be reduced by the mindfulness component of decentering, i.e. the insight that experiences are impermanent mental states. In Experiment 1, participants vividly imagined an unpleasant autobiographical event (1a, 1b) or a rewarding food (1c). When instructed to adopt a decentering perspective in comparison to an immersed perspective during imagery, participants experienced less negative affect and fewer cravings to eat. In Experiment 2, participants were exposed to an attractive or a neutral food, and we assessed salivation and eating-related imagery. While imagery did not differ between groups, the attractive food elicited less salivation in decentering relative to control participants. We suggest that decentering can make one's imagery of consuming a food and of reliving of negative experiences less compelling, and thus reduce affective responses to both unpleasant and rewarding imagery, even if the imagery itself is kept active in mind.

Keywords: mindfulness, imagery, grounded cognition, motivation, decentering

Introduction.

People are frequently exposed to unpleasant or rewarding stimuli in the environment, which may evoke the motivation to act in a certain way, such as in the form of negative affect or cravings to eat unhealthily. This motivation often results from mental imagery, i.e. thoughts expressed as a seemingly real experience of a past or potential future situation (see elaborated intrusion theory of desire; May, Kavanagh, Andrade, 2015; see grounded cognition theory of desire Papies & Barsalou, 2015). Being exposed to attractive food, for instance, can elicit mental imagery of consuming it (Chen, Papies, & Barsalou, 2016; Keesman, Aarts, Vermeent, Häfner, & Papies, 2016). Importantly, vividly elaborating on imagery, i.e. immersing oneself in it, or processing imagery as a permanent and accurate reflection of reality, increases motivational responses such as cravings (May et al., 2015; Papies & Barsalou, 2015). While it is evident that imagery plays an important role in inducing motivational responses, there is a gap in the understanding of how these responses to imagery can be modulated. Here, we examine the role of mindfulness in reducing motivational responses triggered by mental imagery.

Mindfulness-based interventions have become popular as a way to reduce undesired reactions associated with imagery, such as anxiety, depression, and unhealthy eating (for meta-analyses, see Hofmann, Sawyer, Witt, & Oh, 2010; Katterman, Kleinman, Hood, Nackers, & Corsica, 2014). However, the underlying mechanisms of such effects are not fully understood (Tapper, 2018). As one example, the body-scan, which is a typical mindfulness-based exercise, has been found to reduce mental imagery (May, Andrade, Batey, Berry, & Kavanagh, 2010), because it taxes working memory (van den Hout et al., 2011; Tapper, 2018). Furthermore, people high in trait mindfulness have decreased intrusive imagery, are better able to stop their imagery, and can better distract themselves from it (Ostafin, Kassman, & Wessel, 2013). Similarly, guided imagery interventions have similar short-term

effects as decentering (Schumacher et al., 2018; Turner & Tapper, 2018). These findings suggest that mindfulness prevents undesired reactions by reducing mental imagery (Tapper, 2018).

Here, we suggest an additional mechanism, namely that the decentering component of mindfulness can even reduce reactions to mental imagery while the imagery is kept active in mind. Decentering is the insight that experiences are impermanent mental events, rather than permanent states reflecting an objective reality (Bishop et al., 2004; Dreyfus, 2011; see also Tang, Hölzel, & Posner, 2015). This insight can make one's thoughts, such as imagery of consumption or distress, less "real" or compelling, potentially reducing further elaborations, and making it easier to disengage from them (Chiesa, Anselmi, & Serretti, 2014; Keesman et al., 2017; Baquedano, Vergara, Lopez, Fabar, Cosmelli, & Lutz, 2017; Papies & Barsalou, 2015). With regard to the consumption and reward imagery that contributes to food cravings, for example, applying decentering can reduce the degree to which one gets immersed in one's thoughts about the taste, texture, and reward from a food (see Papies, 2013), and can reduce the tendency to elaborate these thoughts into full-blown cravings.

Previous research has indeed found that decentering is correlated with reduced negative affective reactions, such as pain, anxiety, and depression (Fresco et al., 2007; Hoge et al., 2014; Lau et al., 2006; Shoham, Goldstein, Oren, Spivak, & Bernstein, 2017) and with reduced cravings for food (Papies, Winckel, & Keesman, 2016), that it reduces impulses to grab food (Papies, Barsalou, & Custers, 2012), and facilitates healthier eating behavior (Jenkins & Tapper, 2014; Moffitt, Brinkworth, Noakes, & Mohr, 2012; Papies, Pronk, Keesman, & Barsalou, 2015; Hulbert-Williams et al., 2017). The decentering component of mindfulness thus plays a key role in reducing reactions to unpleasant stimuli (Bernstein et al., 2015), and to rewarding stimuli (Keesman, Aarts, Häfner, & Papies, 2017). This earlier research has, however, not tested whether decentering reduces mental imagery directly,

similar to the body scan, or reduces reactions to mental imagery (e.g. Hoge et al., 2014; Papies et al., 2012, 2015). The current research was therefore designed to examine whether decentering can reduce reactions to mental imagery, even when imagery is kept active in mind.

The current research.

To systematically test the idea that decentering reduces reactions to mental imagery, while imagery is kept active in mind, we conducted four experiments, including two replication experiments. Across experiments, we predicted that decentering would reduce affective and appetitive responses, even while participants were actively imagining unpleasant or rewarding experiences.

Experiment 1a.

Experiment 1a was designed to test the hypothesis that applying decentering reduces negative affect to imagery of an unpleasant event. The experiment consisted of two sessions. In one session, participants imagined an unpleasant autobiographic experience and applied an immersed perspective to this imagery. In the other session, participants imagined the same experience and applied a decentering perspective. Thus, participants were always instructed to vividly imagine the unpleasant experience. Differences between conditions can thus not be explained by suppression or distraction. Furthermore, participants imagined the same autobiographical experience in both sessions to keep the content of the mental imagery as similar as possible. To rule out carry-over effects of the decentering manipulation, the order of the sessions was counter-balanced, sessions were held on different days one week apart, and participants were randomly assigned to an order. While we realize that these 3-minute decentering instructions to non-meditators are far removed from teaching mindfulness through extensive meditative practice, this approach yields high experimental control and

rules out effects of other mindfulness-related aspects such as acceptance, compassion, or of previous meditation experience.

Methods.

Design and participants.

Affect in response to the mental imagery of an unpleasant autobiographic event was examined in a 2 (instruction: mental imagery + immersion vs. mental imagery + decentering; within-participants) x 2 (order: immersion first vs. decentering first; between-participants) mixed design with random assignment to order.

A total of 21 participants completed both sessions of the experiment (8 males; age M = 21)[1]. All participants were recruited on a university campus. On average, there were seven days between the two sessions. One additional participant completed the first but not the second session of the experiment and was therefore excluded from any analyses.

Materials.

Instruction. The instructions for the decentering and control perspectives were of similar length and structure, took about 3 minutes, and were both based on a 12-minute decentering and immersion induction by Papies, Pronk, Keesman, & Barsalou (2015). The instructions were provided to participants using a pre-recorded audio fragment, through noise-cancelling headphones, see the Supplemental Materials for the exact instructions.

For mental imagery + decentering (presented to participants as "observing thoughts as fleeting"), participants were instructed to imagine an unpleasant autobiographic event and to observe their thoughts as transient, or "fleeting", mental events that arise and dissipate. We explained this perspective by using the metaphor of observing the stream of water in a

[1] An a-priori power analysis, which we conducted before we decided to apply Bayesian statistics, showed that a minimum sample of 7 would be required to detect the hypothesized within-participant effect of instruction (two tailed α = .05, 95% power, and a Cohen's d point estimate of 1.71 based on a pilot study; we did not expect an effect of order), but we preferred to have a larger sample in case the pilot overestimated the true effect size.

waterfall. We told participants not to resist this stream, and to not pretend that it does not exist, but rather to observe how the stream passes by. Participants were instructed to become aware of all thoughts and reactions, and to observe these as passing events. To prevent demand effects due to participants' preconceived notions of mindfulness, no mention was made of mindfulness, acceptance, or meditation.

For mental imagery + immersion (presented to participants as "immersing in thoughts"), participants were instructed to imagine an unpleasant autobiographic event and to immerse themselves into their thoughts about the event as if it were happening right now. We illustrated this with the experience of thinking back to a funny event, where one can recall the event in detail, which might even spontaneously trigger a smile.

Affect scale. Participants responded to "how did you feel after applying [name of instruction] to your own thoughts?" on three scales with different anchors, from 1 (very negative; very unpleasant; very bad, respectively) to 7 (very positive; very pleasant; very good, respectively). The scores were averaged to a mean affect measure, which constituted the main dependent variable, Cronbach's α = .71.

Manipulation check. As a manipulation check, participants reported their decentering experiences on three items: "while applying [name of instruction] I saw myself as separate from my thoughts", "while applying [name of instruction] my thoughts felt very real (recoded)", and "sometimes you have thoughts and it feels as if what you are thinking about is really happening right now. While applying [name of instruction], to what extent did your thoughts feel like they were really happening right now? (recoded)". This was done on a scale from 1 (not at all applicable to me) to 7 (very applicable to me). The items were based on a decentering and awareness questionnaire (Papies, Winckel, & Keesman, 2016). The scores were averaged to a mean self-reported decentering measure, Cronbach's α = .68.

Imagery. We assessed strength of imagery by asking participants to rate their agreement with two statements on a scale from 1 (not at all applicable to me) to 7 (very much applicable to me): "In some cases thoughts are clear, including many details, in other cases they are not. While applying [name of instruction] my thoughts were very clear.", and "While applying [name of instruction] my thoughts included many details". The two items were averaged to a mean vividness score, Cronbach's α = .71.

Imagery and decentering in daily life. Participants were asked "In daily life, do you experience your thoughts as [name of instruction]?" and responded on a scale from 1 ((almost) never) to 7 (very often).

Procedure.

An overview of the procedure of Experiment 1a can be seen in Figure 1. When no interaction was required, the experimenter sat out of sight behind a room partition. Participants first read and then signed an informed consent form. Participants were told that the study was about ways to approach one's thoughts. The experiment started by asking participants to write down a keyword of a past event that still negatively affected them when thinking back to that event. They were asked to summarize this event into three keywords. Then, participants received the mental imagery + decentering or mental imagery + immersion instruction. Participants were given the opportunity to ask questions to the experimenter, and then continued. Next, the keywords they had entered appeared on the screen to remind them of the autobiographic event. Participants were instructed to press the spacebar to indicate that they had started imagining the unpleasant experience, while applying decentering or immersion, depending on instruction. After 30 seconds, a sound signal informed the participants that they could stop applying the instructions. Participants then responded to the affect scale, manipulation check, and the other questionnaires. Then, participants relaxed for 5-minutes while listening to a music fragment of Delibes' Coppelia, which has been shown to

uplift participants' moods (Västfjäll, 2002). This was included to neutralize any potentially negative mood-states. Afterwards, participants scheduled their second session in the lab.

During the second session, the procedure was repeated as in the first session, using the same keywords of the past event, but with the other instruction (mental imagery + decentering or mental imagery + immersion). At the end of the second session, additional questions were asked about into the original experience of the unpleasant event, such as: "How long ago did the situation of the memory take place?" and "How did you experience the situation of the memory when it took place?" (1-very negative to 7- very positive). We asked whether participants were aware that the research was about mindfulness, what they thought the research was about and what expected findings would be, whether they had mindfulness experience, and whether they did their best to apply our instructions. Finally, participants were debriefed, thanked, and received a small remuneration.

Results.

Analysis strategy.

For the statistical analyses, we used a Bayesian approach to t-test and ANOVA (see Rouder, Morey, Speckman, & Province, 2012; Rouder, Morey, Verhagen, Swagman, & Wagenmakers, 2016).

Manipulation check.

A Bayesian repeated measures ANOVA on participants' self-reported decentering scores with instruction, order, and their interaction term, provided decisive evidence that a decentered perspective was induced for decentering participants (immersion first M = 5.00, SD = 1.05; decentering first M = 4.58, SD = 0.92) relative to immersion participants (immersion first M = 3.30, SD = 0.92; decentering first M = 3.73, SD = 1.25), $BF_{1,0}$ = 1944. No conclusions can be drawn concerning a main effect of order, $BF_{1,0}$ = 0.73, or interaction effect with order, $BF_{1,0}$ = 1.86.

Testing whether decentering reduces negative affect to unpleasant imagery.

There was decisive evidence for the hypothesis that during imagery of the unpleasant experience, applying decentering reduced negative affect relative to applying immersion, $BF_{1,0} = 2944$. The mean affect values of each individual participant in both conditions are displayed in Figure 2. There was no informative evidence suggestive of a main effect of order, $BF_{1,0} = .46$, or interaction with order, $BF_{1,0} = .68$.

Comparing the amount of imagery between conditions

There was evidence suggesting that the vividness of people's imagery was increased when applying immersion ($M = 5.00$, $SD = 1.10$) relative to applying decentering ($M = 4.07$, $SD = 1.43$), $BF_{1,0} = 7.45$. There was no informative evidence suggestive of a main effect or interaction with order, respectively $BF_{1,0} = .0.49$ and $BF_{1,0} = .89$.

Exploratory analyses.

Using Bayesian regression analyses, we explored the effects of self-reported imagery and self-reported decentering (from the manipulation check) on self-reported affect during the decentering sessions. There was some evidence suggesting that self-reported decentering predicted positive affect, $BF_{1,0} = 3.63$. There was no such evidence for imagery scores, $BF_{1,0} = 0.58$. This suggests that participants applying decentering did not reduce negative affect by reducing imagery.

Descriptive statistics of the unpleasant event.

The unpleasant events that participants imagined during the experiment took place 4.62 years ago on average ($SD = 4.05$; min = still ongoing, max = 15 years ago). At the time of the actual event, participants experienced it as very negative, as indicated on an affect scale from 1 (very negative) to 7 (very positive), with $M = 1.71$ ($SD = .72$). Examples of keywords provided by participants were: "cancer, diagnosis, dad" and "broken jaw, hospital, study delay".

Conceptual replications in Experiment 1b and 1c

Experiment 1b (N = 22, 4 males) had the same design, and again with experienced affect as dependent variable. The major difference with Experiment 1a was that the instructions in Experiment 1b were provided by the experimenter, rather than in automatized manner through headphones. In addition, participants responded to three open questions after each of the sessions, which were not formally analyzed: "what did you exactly do while adopting [name of perspective] towards your thoughts?", "what thoughts did you have during [name of perspective] while adopting [name of perspective]?", "how did you experience these thoughts during [name of perspective], and how did you feel?". The results again showed very strong evidence for the hypothesis that applying decentering reduces negative affect to unpleasant imagery, $BF_{1,0} > 1\ 495\ 000$. There was little informative evidence for or against a main effect of order, $BF_{1,0} = .45$, or for an interaction effect of order and instruction, $BF_{1,0} = .72$.

Experiment 1c (N = 30, 6 males) again had the same design and assessed food cravings in response to mental imagery of an attractive yet unhealthy snack. Here, participants were tested in the same session rather than one week apart as in Experiment 1a and 1b, because food preferences are highly context–dependent (Meiselman, 2006). Similar to Experiment 1b, the instructions were delivered in person and participants again responded to the three open questions after each of the sessions. The results showed decisive evidence for the hypothesis that applying decentering reduced craving reactions to mental imagery of an attractive snack, $BF_{1,0} = 111$.

The results of Experiment 1a were thus conceptually replicated by both Experiment 1b and 1c, showing that decentering reduces reactions to mental imagery of both unpleasant and rewarding experiences.

Summary.

In sum, participants imagined an autobiographic experience while applying immersion, and while applying decentering. There was very strong evidence that applying decentering reduced negative affective reactions to unpleasant imagery (Experiment 1a and 1b), and reduced cravings to rewarding imagery (Experiment 1c), even when imagery was kept active in mind. Although imagery was somewhat reduced when participants applied decentering relative to immersion, self-reported imagery did not predict affect, and thus reduced imagery cannot explain the effect of decentering. One alternative explanation, however, is that differences between conditions result from increased negative affect when applying an immersion perspective, rather than from decreased negative affect due to decentering. An important question that remains is thus whether decentering also reduces reactions to a more neutral control perspective.

Experiment 2.

This experiment built further on the findings of Experiment 1. The research design was improved in three important ways. First, instead of merely working with imagery, we exposed participants to an attractive and a neutral food: a bowl of crisps and bread with cheese. Second, we used salivation as a physiological measure, rather than using self-report measures as in Experiment 1a, 1b, and 1c. Salivation in response to food cues reflects the body's preparatory response to eat (Spence, 2011) and is less susceptible to demand effects than self-report measures, making it unlikely that any effects of decentering are due to participants responding in a socially desirable manner. Third, instead of an immersion instruction, control participants were simply exposed to the food without any further instructions. Any differences between conditions can then be more clearly attributed to decentering, rather than to the immersion instructions. We now used a between-participants design, as carry-over effects of decentering might be more likely with exposure as a control condition. Finally, at the end of the experiment, participants reported their mental imagery of

consumption. This allowed us to compare levels of imagery between participants who were only exposed to the food, and those who also applied decentering.

We hypothesized that applying decentering would reduce salivation to the attractive food relative to food exposure only. Furthermore, we hypothesized that the attractive food would elicit greater mental imagery of consumption for both the exposure and decentering participants, relative to a neutral food (Keesman et al., 2016). Evidence of no difference in mental imagery between decentering and exposure groups would then provide initial support for the idea that decentering reduces reactions to mental imagery, instead of merely reducing mental imagery itself.

Methods.

Design and participants.

Salivation was examined in a 2 (instruction: exposure vs. exposure + decentering; between-participants) x 2 (food type: attractive vs. neutral; within-participants) x 2 (order: attractive food first vs. neutral food first; between-participants) design with random assignment to conditions.

Sixty participants recruited at a university campus completed the experiment (17 males; age M = 22, BMI M = 21). The sample size was chosen to be similar to a previous experiment using the salivation paradigm (Keesman et al., 2016). During recruitment, participants were told that they could only sign up for participation if they liked crisps. Furthermore, all participants had to agree to not eat for one hour before participation. This was to ensure that participants were not fully satiated when starting the experiment, and to reduce the amount of food residue in their mouths.

Materials.

Salivation amount. The cups were pre-weighed using a 0.01-gram precision scale. Participants saw the object for one minute, and afterwards, they spit their saliva in a cup (for

the full instructions, see Keesman et al., 2016). The amount of saliva was calculated by subtracting the pre-spitting weight from the post-spitting weight.

Questionnaire assessing imagery about consumption. To assess whether participants had imagined eating the foods, participants responded to a mental imagery of consumption questionnaire consisting of 5 items (e.g. "I imagined how it would be to eat [the specific food]"; see also Keesman et al., 2016; Tiggemann & Kemps, 2005). Participants answered these questions for the neutral food and for the attractive food, on scales from 1 (not at all) to 10 (very much), both Cronbach's $\alpha \geq .87$

Decentering experiences. Participants responded to an adapted version of the food-specific decentering questionnaire (e.g. "I considered my thoughts about [the specific food] as transient events in my mind"; Papies et al., 2016), again for the neutral food and the attractive food, on scales from 1 (not at all) to 10 (completely true), both Cronbach's $\alpha \geq .70$.

Food attractiveness. Participants indicated whether they would have liked to eat the neutral and attractive food and whether they liked each food, both on 1-10 scales. We computed an average attractiveness score for each food, both Cronbach's $\alpha \geq .68$.

Additional questions. Additional questions as in Experiment 1a probing for awareness of the research topic were included but not formally analyzed, as well as 2 additional questions on meditation skills "how skilled do you find yourself in terms of applying these meditation techniques?", and "how often do you apply meditation techniques?", on 1-10 scales.

Procedure.

For an overview of the procedure, see Figure 3. Participants were first asked to rinse their mouth using a cup of water. Then, participants indicated current hunger and thirst on 10-point scales (with *M* hunger = 6.1, and *M* thirst =5.5; no differences between conditions). Participants then received instructions on the saliva measure, and a baseline measure of

salivation was taken with a non-food control object (small block of wood). Participants in the exposure condition received no additional instructions. Participants in the decentering condition listened to the decentering instruction, and they were asked to apply decentering to any imagery elicited by the objects that would be presented to them. Participants were then exposed to the neutral food (bread with cheese) or the attractive yet unhealthy food (bowl of crisps), in random order. After the salivation measure was completed, all participants had a 3-minute break. After this, decentering participants were reminded of the decentering instructions, and the salivation procedure was repeated for the other food. Finally, participants completed the questionnaires described above.

Results.

Manipulation checks.

Analyzing participants' decentering scores, there was strong evidence of a main effect of instruction, suggesting that decentering participants had adopted a decentering perspective (for the attractive food, $M = 6.71$, $SD = 1.48$, and for the neutral food, $M = 7.35$, $SD = .97$) relative to exposure participants (for the attractive food, $M = 5.88$, $SD = .97$, and for the neutral food, $M = 6.40$, $SD = 1.34$, respectively), $BF_{1,0} = 12.88$. There was also strong evidence for participants adopting a more decentered perspective towards the neutral food than towards the attractive food, $BF_{1,0} = 13.63$, all other $BF_{1,0} < 1.68$.

Participants found the attractive food more attractive ($M = 7.79$, $SD = 1.73$) than the neutral food ($M = 5.85$, $SD = 2.53$), $BF_{1,0} = 10762$, with no main or interaction effects of instruction, or order of exposure, all $BF_{1,0} < .33$.

Testing whether decentering reduces salivation to attractive food

Outlier removal. Following Keesman and colleagues (2016), on which the salivation paradigm was based, we considered data points that differed by more than 3 standard deviations from the mean as outliers and did not include them in the analyses. There was one

outlier each for salivation to the neutral and to the attractive food. Outlier removal did not influence the main conclusions.

Baseline differences. There was anecdotal evidence suggesting that decentering participants salivated less at baseline (M = .20, SD = .16), than exposure participants (M = .31, SD = .18), $BF_{1,0}$ = 2.99. Therefore, we controlled for baseline salivation in the main analysis. To this end, the residuals of salivation were computed and are presented in Figure 4.

Main analyses. Bayesian t-tests provided support for the main hypothesis that decentering participants salivated less in response to the attractive food than exposure participants, $BF_{1,0}$ = 9.00, see Figure 4. There was no evidence for an effect of order $BF_{1,0}$ = .66, nor for an interaction of order with instruction, $BF_{1,0}$ = 1.74

Across conditions, participants salivated more to the attractive food than to the neutral food, $BF_{1,0}$ = 266.58. Across food types, decentering participants salivated less than exposure participants, $BF_{1,0}$ = 19.13. Both of these main effects can be seen in Figure 4. There was anecdotal evidence for an interaction of the applied perspective (decentering or control) with food type, $BF_{1,0}$ = 3.38, and no evidence for other main or interaction effects, all other $BF_{1,0}$ < 1.50.

The effect of decentering or control perspective was also tested for the neutral food. This showed that there was no informative evidence for or against an effect of decentering instruction on salivation to the neutral food, $BF_{1,0}$ = .91, see Figure 4. There was no evidence for an effect of order $BF_{1,0}$ = .22, or for an interaction of order with instruction, $BF_{1,0}$ = .18.

In sum, in line with our hypothesis, applying decentering reduced salivation to the attractive food, and it seemed to affect salivation to the neutral food less.

Examining mental imagery about consumption.

In line with our predictions, there was moderate evidence for the null hypothesis of no difference in amount of consumption imagery between decentering and exposure participants,

for both the attractive food, $BF_{1,0} = .28$, and the neutral food, $BF_{1,0} = .21$. Thus, these findings suggest that imagery about consumption was comparable for decentering and control participants. The evidence additionally suggested that participants imagined consumption more when exposed to the attractive food (for exposure $M = 6.13$, $SD = 1.70$, for decentering $M = 5.56$, $SD = 2.63$) than when exposed to the neutral food (for exposure $M = 4.83$, $SD = 1.76$, for decentering $M = 4.95$), $BF_{1,0} = 1341$. There was no informative evidence suggestive of a main effect or interaction with instruction or order of presentation, all $BF_{1,0} < 1.52$.

Exploratory analyses.

To the question asking participants whether they thought the experiment was about mindfulness (yes/no), 15 out of 28 decentering participants and 3 out of 30 exposure participants indicated "Yes" (2 missing). Adding this as a between-participants factor to the model testing the effect of instruction on salivation did not change the pattern of results.

Summary.

Participants in this experiment were exposed to an attractive yet unhealthy food, and half of participants applied decentering while viewing the food. Control participants spontaneously imagined eating the food, which is in line with earlier findings (see e.g. Keesman et al., 2016). Importantly, decentering participants also imagined eating the food, and our findings indicate that they had similar levels of consumption imagery as control participants. This suggests that decentering participants did not apply thought suppression or distraction, and that they did not replace imagery of eating the food with consumption-unrelated, "cold" imagery (see Mischel & Baker, 1975). Despite this, and in line with the hypothesis, decentering participants salivated less to the attractive food than control participants. These effects are unlikely to be caused by social desirability, as salivation is difficult to consciously control. Furthermore, the effects are unlikely to be driven by the control participants, as these were just exposed to the foods rather than receiving an

instruction to immerse in their imagery of consumption. The findings of Experiment 2 thereby provide strong additional support to the findings of Experiment 1 that decentering can reduce reactions to mental imagery.

General Discussion.

The results of four experiments suggest that decentering can attenuate reactions to mental imagery of rewarding and of unpleasant experiences. Our approach of exclusively manipulating decentering, in isolation from other mindfulness components, allowed us to precisely examine decentering and test the hypothesis that decentering directly reduces reactions to mental imagery, even when this imagery is kept active in mind. Most mindfulness research does not disentangle the different mindfulness components, and often involves the regulation of attention, such as maintaining awareness on the breath or on bodily sensations. In such mindfulness practices, every time imagery is initiated, it is disrupted by returning attention to the chosen target. Consequently, one actively prevents imagery from unfolding (Tapper, 2017). Here, we show that even when this imagery is active in mind, decentering can attenuate reactions to mental imagery.

We suggest that decentering makes imagery less compelling because it reduces immersion and elaboration of one's aversive or rewarding imagery (see Keesman et al, 2017). Several fMRI experiments indeed point in this direction. Among experienced meditators, for instance, during pain stimulation, decentering leads to a decoupling of prefrontal areas from sensory pain areas (Grant, Courtemanche, & Rainville, 2011). This corresponds to reduced cognitive elaboration on this pain and predicted reduced pain. Other research with both experienced meditators and non-meditators shows that decentering reduces activity in the neural network implicated in immersion, reducing identification with one's imagery (Brewer, Elwafi, & Davis, 2013; Brewer & Garrison, 2014; Lebois et al., 2015; Tang, Tang, & Posner, 2013).

Future directions.

Decentering adds to the available psychological tools to reduce undesired reactions, as it can diminish reactions to both unpleasant and rewarding imagery, and to verbal content (e.g. as per cognitive defusion techniques used in acceptance and commitment therapy; Hayes, Strosahl, & Wilson, 2011). Through reducing the influence of short-term affective reactions on behavior, decentering might allow people to guide their behavior with their long-term intentions, such as intentions to eat more healthily. A further benefit of decentering is that it can be taught through a relatively brief instruction, rather than requiring an extensive training as most mindfulness practices. Decentering might thereby be a valuable complement to interventions that aim to increase people's ability to regulate their behavior. However, the current research only measured the short-term effects of a decentering training. It would be valuable to examine the potential for long-term effects, such as how long people can continue using decentering after receiving this brief training, or how the long-term application of decentering can be facilitated.

While we describe the effects of decentering in terms of its positive implications, its use outside the context of a Budhhist ethical framework (Grossman, 2015; Monteiro, Musten, & Compson, 2014) could also have negative effects. For instance, using decentering could be seen as a license for apathy or non-judgment merely because it reduces reactions to imagery (as noted by Keesman et al., 2017; Dreyfus, 2011). In the context of long-term goals such as being compassionate or eating healthily, however, our findings suggest that decentering can serve as a tool to decrease the power of thoughts that could interfere with the pursuit of these goals.

We suggest that decentering goes beyond merely taking distance from one ′ s thoughts, e.g. a fly on the wall perspective (e.g. Kross & Ayduk, 2011; Kross, Ayduk, & Mischel, 2005). The crucial distinction is that decentering involves the insight that

experiences are impermanent in nature and do not reflect an objective reality, making them less compelling, and easier to disengage from. Unlike decentering, which can reduce reactivity to concrete imagery, distancing is only effective when imagery is deliberately analyzed from a broader "why-perspective" (Kross & Ayduk, 2011; Kross, Ayduk, & Mischel, 2005).

Conclusion.

We systematically examined the role of the decentering component of mindfulness for reducing reactions to mental imagery of unpleasant past experiences, and of attractive yet unhealthy foods. The results of four experiments suggest that decentering can dampen reactions to mental imagery as it reduced negative affect, salivation, and cravings to eat unhealthy food. Furthermore, in these meditation-naïve samples, decentering seemed to work by observing the mental imagery as impermanent, rather than by reducing the imagery itself. Overall, this research supports the use of decentering as a tool to reduce reactions to both unpleasant and rewarding imagery.

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Figure 1. Procedure of Experiment 1a.

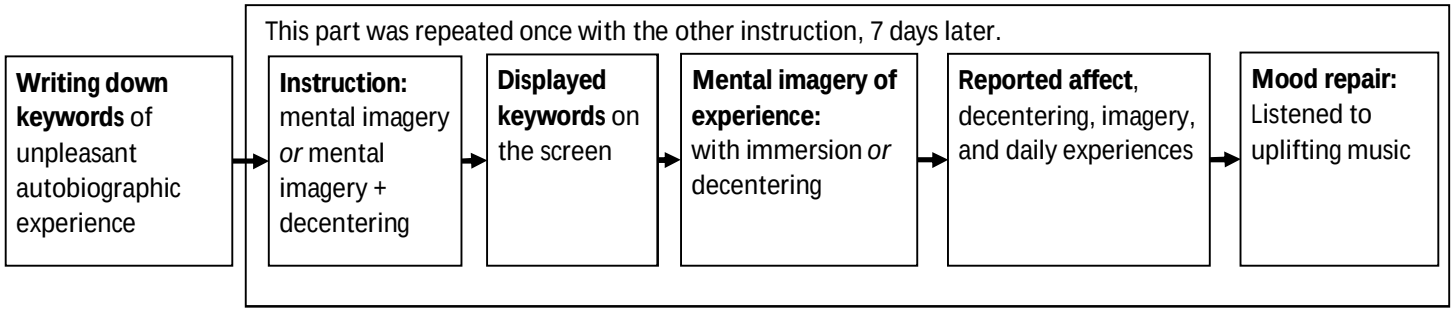


Figure 2. The role of decentering for reducing negative affective reactivity to unpleasant imagery

Each grey line represents one participant, with the dots indicating the experienced affect for the mental imagery + immersion and mental imagery + decentering perspective, ranging from 1 (very negative) to 7 (very positive). The diamond represents the mean affect scores.

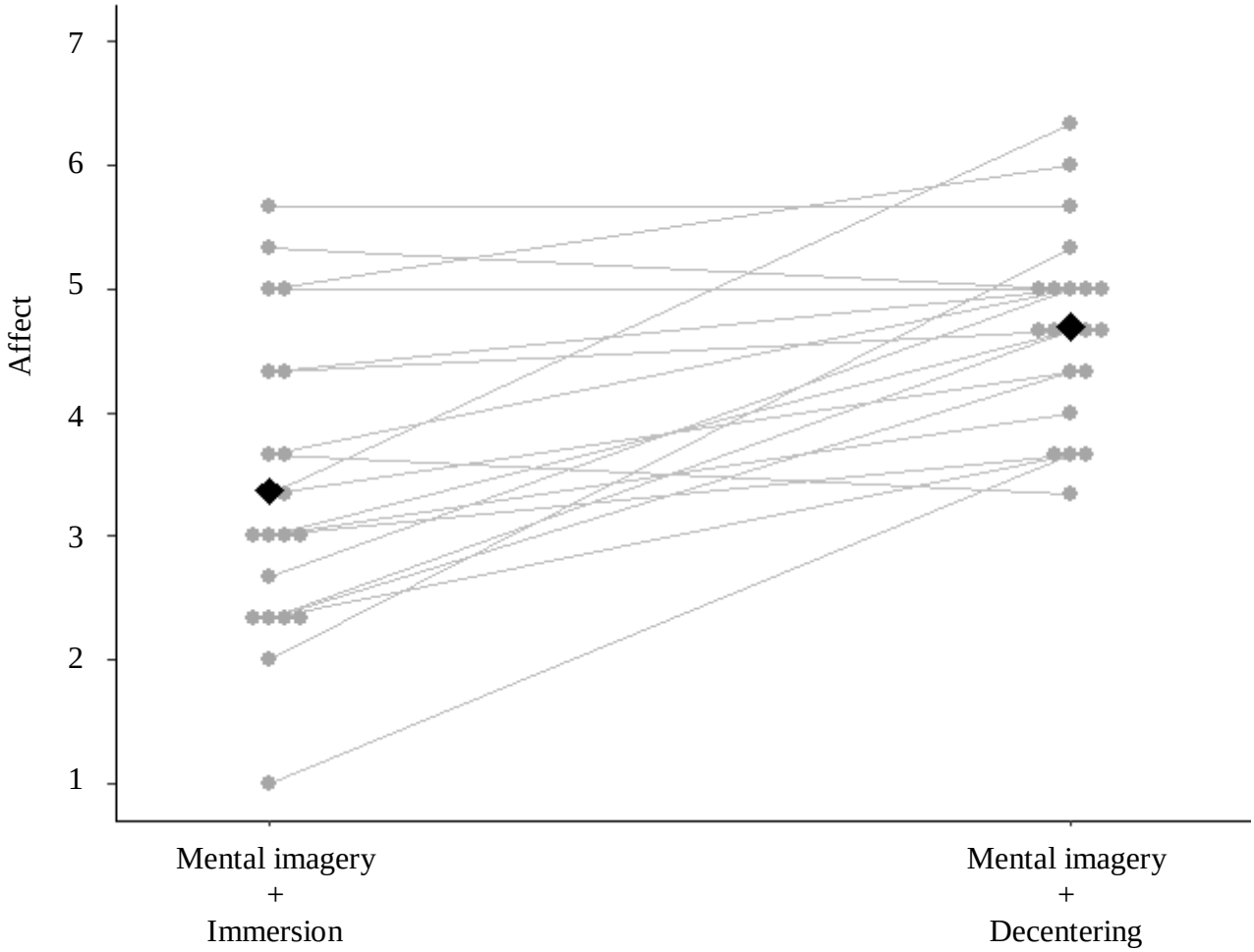


Figure 3. Procedure of Experiment 2.

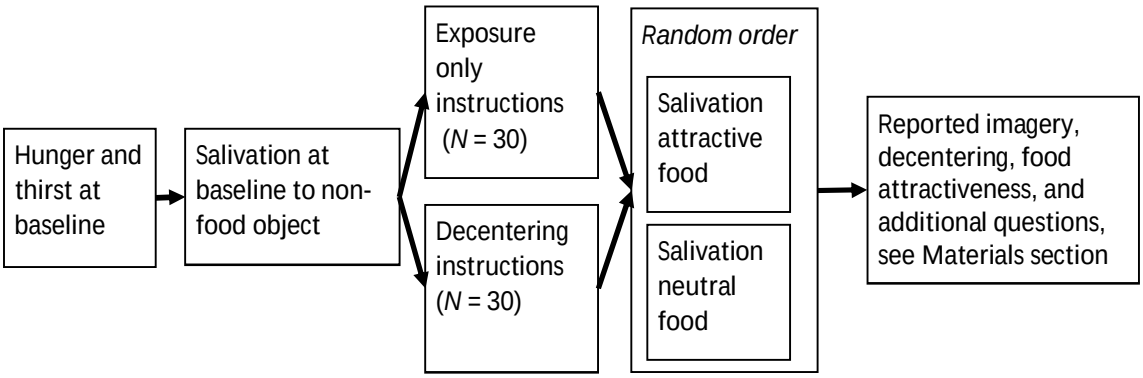
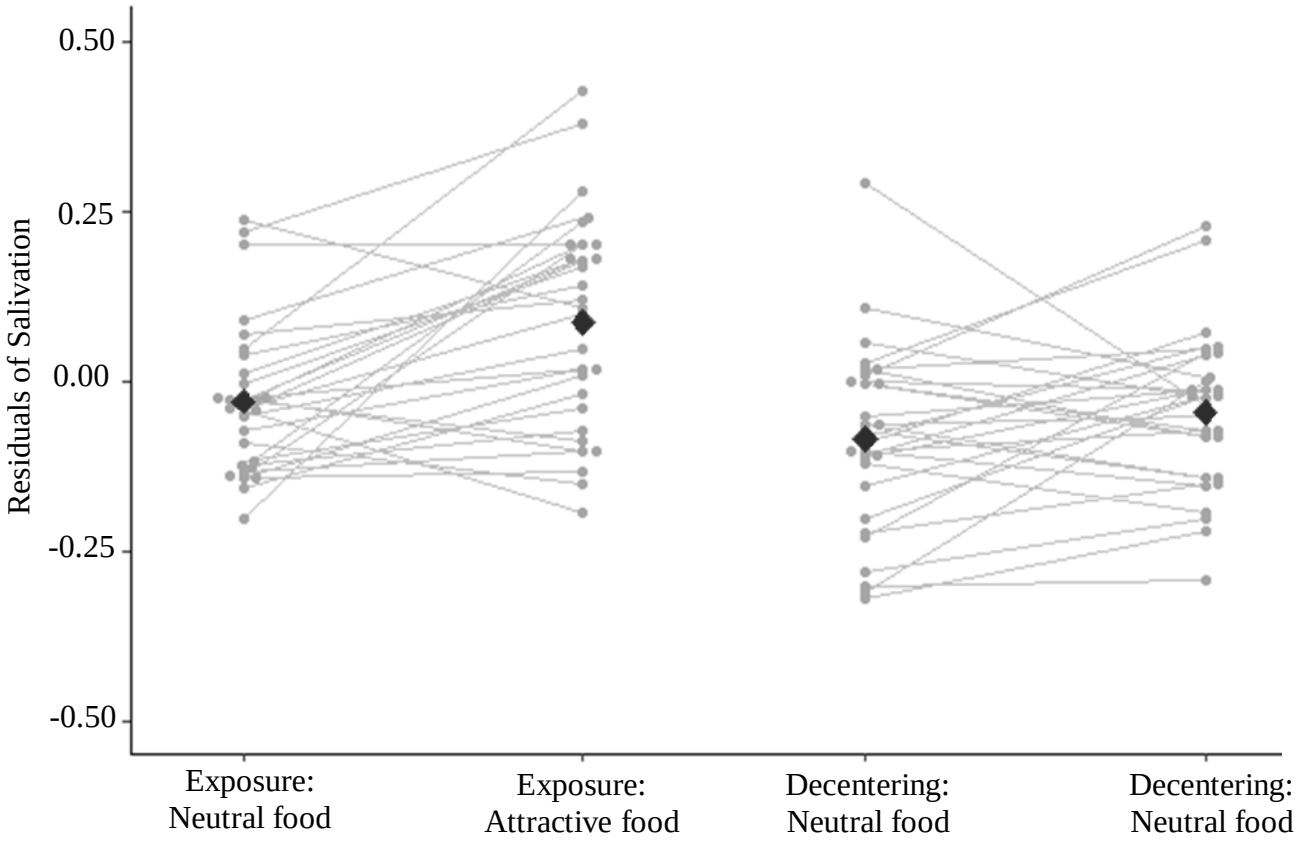


Figure 2. The role of decentering for reducing salivation to food

Each grey line represents one participant, with the dots indicating salivation controlled for baseline, for the neutral and attractive food, for exposure or for decentering participants. The diamond represents the mean salivation scores.



Supplementary material.

Decentering and control instructions.

Instruction for decentering towards unpleasant autobiographic imagery

part	Original in Dutch	Translation to English
Intro	Straks zal je (opnieuw) een manier om met je gedachtes om te gaan uitgelegd krijgen. Deze manier om met je gedachtes om te gaan zal je dan (opnieuw) toepassen op de gedachtes die je hebt bij jouw opgeschreven herinnering. De uitleg over deze manier van met je gedachtes om te gaan zal nu beginnen. Als je op deze manier met je gedachtes omgaat, dan probeer je om je gedachtes te zien als mentale gebeurtenissen die ook weer voorbijgaan. Om dit te illustreren, zal ik een metafoor van een waterval gebruiken.	We will (again) introduce to you a specific way of dealing with your thoughts. Once we have explained this, you will learn to (again) apply this way of dealing with your thoughts to the thoughts that you have in response to the memory that you wrote down. We will now start introducing this way of dealing with your thoughts to you. If you apply this way of dealing with your thoughts, then you try to see your thoughts as mental events, which come and go. I will use the metaphor of a waterfall to illustrate this.
Basic idea	Probeer je even een waterval voor te stellen. De constante stroom aan water is je gedachtegang. Dit houdt niet op, en gaat constant door, en het water kan je ook gemakkelijk mee naar beneden sleuren als je erin terecht komt. Probeer hier geen weerstand tegen de stroming te bieden, en probeer ook niet te doen alsof de waterval niet bestaat. Maar ga eens achter de waterval staan. Op die manier kan je gewoon kijken naar al het water dat voorbij komt. Zo kun je dus ook met je gedachtes omgaan. Observeer de gedachtes die je hebt, en zie hoe ze opkomen en voorbijgaan.	Try to imagine a waterfall. The constant stream of water is like your stream of thoughts. It does not stop, it goes on continuously, and the water can easily carry you down/away *(note: the Dutch verb meesleuren is more violent than that)* if you end up in it. Don't try to resist this stream, and don't try to pretend that this waterfall does not exist. Simply try to step behind the waterfall (for once). This way, you can simply look at all the water that is passing by. You can also deal with your thoughts this way. Observe the thoughts that you have, and look at them come up and dissipate.
How to apply it	Ik wil je nu graag vragen om deze manier van omgaan met je gedachtes toe te passen op de herinnering die je eerder hebt opgeschreven. Maar hoe kun je dit het beste doen? Als je bijvoorbeeld terugdenkt aan de gebeurtenis, of een bepaalde emotie	We would now like to ask you to apply this way of dealing with your thoughts to the memory that you wrote down. How can you best do this? If, for example, you are remined of a certain event, or experience a certain emotion, try to be aware

	ervaart, wees dan bewust van de aspecten van die gebeurtenis, maar blijf ook bewust van waar je je nu bevindt (op een stoel in deze kamer). Probeer de gedachtes, fysieke reacties, en emoties die bij je opkomen op te merken, maar realiseer je dat het gewoon maar mentale gebeurtenissen zijn. Het zijn maar voorbijgaande verschijnselen die je hersenen produceren. En omdat dit zo is, hoef je er ook niets mee te doen, deze gedachtes gaan altijd uit zichzelf gewoon weer weg. Dus net als bij het water in de waterval, observeer gewoon hoe je gedachtes voorbij stromen.	of these thoughts about the event, but also try to stay aware of where you are right now – on a chair, in this room. Try to note/notice the thoughts, physical reactions, and emotions that come up in you. But also realize that these are merely mental events. They are passing phenomena that are being produced by your brain. And because of that, you don't have to do anything about them. These thoughts will always disappear by themselves. Just like the water in the waterfall, simply try to observe how your thoughts stream float by.
How to apply it – what can happen	Sommige gedachtes kunnen confronterend zijn, maar probeer ze niet te onderdrukken of te vermijden. Merk op hoe ze opkomen en weer verdwijnen. Net als dat je niet hoeft te reageren op een paar druppels water, zo hoeft dat ook niet bij deze gedachtes. Als je deze manier van met je gedachtes omgaan toepast, dan zal je misschien alsnog soms even worden meegesleept in je gedachtes. Dit gebeurt soms gewoon en is eigenlijk heel natuurlijk. Zodra je dat merkt, laat het dan gewoon los omdat het maar een mentale gebeurtenis is, en probeer dan weer dit perspectief aan te nemen waar je observeert hoe je gedachtes opkomen en weer verdwijnen.	Some thoughts can be confronting, but try not to suppress them or to avoid them. Simply note how they come up and disappear again. Just like you don't have to react to a few drops of water, you don't have to react to these thoughts. If you apply this way of dealing with your thoughts, you could still find yourself being carried away in your thoughts sometimes. This simply happens sometimes and is actually very natural. As soon as you notice this, just let it go, because it is only a mental event, and try to again adopt the perspective of observing how your thoughts arise and dissipate.
Check	Is het duidelijk wat ik bedoel met deze manier van je gedachtes beschouwen als voorbijgaande mentale gebeurtenissen?	Is it clear what I mean with this way of dealing with your thoughts as passing mental events clear to you?
Apply to autobiographic memory	Straks gaan we hiermee een korte oefening doen van 30 seconden. Je krijgt dan (weer) de kernwoorden te zien van de herinnering die je eerder hebt opgeschreven. Ik wil je dan vragen	Soon, we will start applying this perspective in a brief exercise of 30 seconds. You will (again) be shown the keywords of the memory that you wrote down earlier. I would like to ask you to reimagine this memory.

	om deze herinnering voor de geest te halen. Als je dat hebt gedaan mag je je ogen dichtdoen en met de oefening beginnen. Probeer dan alle gedachten en reacties die je bij je herinnering hebt te zien als voorbijgaand, dus als mentale gebeurtenissen die opkomen ne weer verdwijnen.	Once you have done that, you can close your eyes and start with the exercise. Try to see all your thoughts and reactions that you have with your memory as passing, in other words, as mental events that come up and dissipate again.
Stay grounded	Terwijl je dit doet kan het helpen om je bewust te blijven van de situatie waarin je nu bent, voel hiervoor bijvoorbeeld je lichaam op de stoel zitten, en voel hoe je voeten op de vloer staan.	While you are doing this, it can sometimes be helpful to try to remain aware of the situation in which you currently are. Try, for example, to feel your body rest on the chair, and feel how your feet are resting on the ground.
Check	Heb je nog vragen over deze oefening?	Do you have any more questions about this exercise?

Instruction for immersion towards unpleasant autobiographic imagery

part	Original in Dutch	Translation to English
Intro	Straks zal je (opnieuw) een manier om met je gedachtes om te gaan uitgelegd krijgen. Deze manier om met je gedachtes om te gaan zal je dan (opnieuw) toepassen op de gedachtes die je hebt bij jouw opgeschreven herinnering. De uitleg over deze manier van met je gedachtes om te gaan zal nu beginnen. Als je op deze manier met je gedachtes omgaat, dan probeer je om helemaal op te gaan in je gedachtes. Om dit te illustreren, zal ik een voorbeeld van een grappige herinnering gebruiken.	We will (again) introduce to you a specific way of dealing with your thoughts. Once we have explained this, you will learn to (again) apply this way of dealing with your thoughts to the thoughts that you have in response to the memory that you wrote down. We will now start introducing this way of dealing with your thoughts to you. If you apply this way of dealing with your thoughts, then you try to completely immerse yourself in your thoughts. To illustrate this, I will use an example of a funny memory
Basic idea	Bijvoorbeeld, als je op straat loopt en aan iets leuks of grappigs terugdenkt, dan begin je vaak spontaan te glimlachen. Het is net of je er echt bent, alsof het nu gebeurt, en alle gedachtes en ervaringen van toen stel je je dan ook heel levendig voor. Ook lichamelijk kan dit heel sterk terugkomen, zoals met die glimlach.	For instance, when walking down the street and remembering something funny, this can instantly make you smile. It is like you are actually there, as if it is happening right now, and you vividly imagine all thoughts and memories from back then. This can also come back in a bodily form, such as with that instant smile.
How to apply it	Ik wil je nu graag vragen om deze manier van omgaan met je gedachtes toe te passen op de herinnering die je eerder hebt opgeschreven. Maar hoe kun je dit het beste doen? Probeer je heel levendig de gebeurtenis voor te stellen. Ga hiervoor terug in de tijd en herleef deze ervaring. Denk dus bijvoorbeeld terug aan waar je was, hoe iedereen keek, wat er werd gezegd, wat je dacht, en wat je voelde in je lichaam. Ervaar dus alle emoties, gedachtes, en hoe het voelt in je lichaam, alsof het nu echt gebeurt.	We would now like to ask you to apply this way of dealing with your thoughts to the memory that you wrote down. How can you best do this? Try to vividly imagine the event from your memory. To do so, go back in time and relive this experience. Reimagine, for instance, where you were, how everyone looked, what was said, what you thought, and what you felt in your body. In other words, experience all emotions, thoughts, and how it feels in your body, as if it were actually happening right now.
Check	Is het duidelijk wat ik bedoel met deze manier van in je gedachtes opgaan?	Is it clear what I mean with immersing with your thoughts this way?
Apply to autobiographic memory	Straks gaan we hiermee een korte oefening doen van 30 seconden. Je krijgt dan (weer) de kernwoorden te zien van de herinnering die je eerder hebt opgeschreven. Ik wil je dan vragen	Soon, we will start applying this perspective in a brief exercise of 30 seconds. You will (again) be shown the keywords of the memory that you wrote down earlier. I

	om deze herinnering voor de geest te halen. Als je dat hebt gedaan mag je je ogen dichtdoen en met de oefening beginnen. Probeer dan helemaal op te gaan in alle gedachtes en reacties die je bij je herinnering hebt, dus stel ze je heel levendig voor alsof ze nu echt gebeuren.	would like to ask you to reimagine this memory. Once you have done that, you can close your eyes and start with the exercise. Try to then immerse yourself in all your thoughts and reactions that you have with your memory. In other words, lively imagine them as if they were happening right now.
Check	Heb je nog vragen over deze oefening?	Do you have any more questions about this exercise?

Instruction for decentering towards food-related imagery

part	Original in Dutch	Translation to English
Intro	Straks zal je (opnieuw) een manier om met je gedachtes om te gaan uitgelegd krijgen. Deze manier om met je gedachtes om te gaan zal je dan (opnieuw) toepassen op de gedachtes die je hebt [bij jouw opgeschreven voedselproduct]/ [bij het product dat voor jou wordt neergezet]. De uitleg over deze manier van met je gedachtes om te gaan zal nu beginnen. Als je op deze manier met je gedachtes omgaat, dan probeer je om je gedachtes te zien als mentale gebeurtenissen die ook weer voorbijgaan. Om dit te illustreren, zal ik een metafoor van een waterval gebruiken.	We will (again) introduce to you a specific way of dealing with your thoughts. Once we have explained this, you will learn to (again) apply this way of dealing with your thoughts to the thoughts that you have in response to [the food product that you wrote down]/ [the product placed in front of you]. We will now start introducing this way of dealing with your thoughts to you. If you apply this way of dealing with your thoughts, then you try to see your thoughts as mental events, which come and go. I will use a metaphor of a waterfall to illustrate this.
Basic idea	Probeer je even een waterval voor te stellen. De constante stroom aan water is je gedachtegang. Dit houdt niet op, en gaat constant door, en het water kan je ook gemakkelijk mee naar beneden sleuren als je erin terecht komt. Probeer hier geen weerstand tegen de stroming te bieden, en probeer ook niet te doen alsof de waterval niet bestaat. Maar ga eens achter de waterval staan. Op die manier kan je gewoon kijken naar al het water dat voorbij komt. Zo kun je dus ook met je gedachtes omgaan. Observeer de gedachtes die je hebt, en zie hoe ze opkomen en voorbijgaan.	Try to imagine a waterfall. The constant stream of water is like your stream of thoughts. It does not stop, it goes on continuously, and the water can easily carry you down/away *(note: the Dutch verb meesleuren is more violent than that)* if you end up in it. Don't try to resist this stream, and don't try to pretend that this waterfall does not exist. Simply try to step behind the waterfall (for once). This way, you can simply look at all the water that is passing by. You can also deal with your thoughts this way. Observe the thoughts that you have, and look at them come up and go away again.
How to apply it	Hoe kun je dit het beste doen? Als je bijvoorbeeld gedachten hebt bij een voedselproduct, wees hier dan bewust van, maar blijf ook bewust van waar je je nu bevindt (op een stoel in deze kamer). Probeer de gedachtes, fysieke reacties, en emoties die bij je opkomen op te merken, maar realiseer je dat het gewoon maar mentale gebeurtenissen zijn. Het zijn maar voorbijgaande	How can you best do this? If, for example, you have thoughts about a food product, try to be aware of these thoughts, but also try to stay aware of where you are right now – on a chair, in this room. Try to note/notice the thoughts, physical reactions, and emotions that come up in you. But also realize that these are merely mental events. They are passing phenomena that are being produced by your brain. And because

	verschijnselen die je hersenen produceren. En omdat dit zo is, hoef je er ook niets mee te doen, deze gedachtes gaan altijd uit zichzelf gewoon weer weg. Dus net als bij het water in de waterval, observeer gewoon hoe je gedachtes voorbij stromen.	of that, you don't have to do anything about them. These thoughts will always disappear by themselves. Just like the water in the waterfall, simply try to observe how your thoughts stream float by.
How to apply it – what can happen	Sommige gedachtes kunnen confronterend zijn, maar probeer ze niet te onderdrukken of te vermijden. Merk op hoe ze opkomen en weer verdwijnen. Net als dat je niet hoeft te reageren op een paar druppels water, zo hoeft dat ook niet bij deze gedachtes. Als je deze manier van met je gedachtes omgaan toepast, dan zal je misschien alsnog soms even worden meegesleept in je gedachtes. Dit gebeurt soms gewoon en is eigenlijk heel natuurlijk. Zodra je dat merkt, laat het dan gewoon los omdat het maar een mentale gebeurtenis is, en probeer dan weer dit perspectief aan te nemen waar je observeert hoe je gedachtes opkomen en weer verdwijnen.	Some thoughts can be confronting, but try not to suppress them or to avoid them. Simply note how they come up and disappear again. Just like you don't have to react to a few drops of water, you don't have to react to these thoughts. If you apply this way of dealing with your thoughts, you could still find yourself being carried away in your thoughts sometimes. This simply happens sometimes and is actually very natural. As soon as you notice this, just let it go, because it is only a mental event, and try to again adopt the perspective of observing how your thoughts arise and dissipate.
Check	Is het duidelijk wat ik bedoel met deze manier van je gedachtes beschouwen als voorbijgaande mentale gebeurtenissen?	Is it clear what I mean with this way of dealing with your thoughts as passing mental events clear to you?
Apply to food	Nu zal je wat je hebt geleerd tijdens de oefening gaan toepassen op jouw eigen gedachten. Ik wil je vragen om [het voedselproduct die je aan het begin van het onderzoek hebt opgeschreven voor de geest te halen] / [je te focussen op het product voor je]. Probeer dan alle gedachten en reacties die je bij dit voedselproduct hebt te zien als voorbijgaand, dus als mentale gebeurtenissen die opkomen en weer verdwijnen.	Now, you will start applying what you have learned on your own thoughts during an exercise. I want to ask you to [reimagine the food product, the one that you wrote down at the start of the research study] / [focus on the product in front of you]. Try to then see all your thoughts and reactions that you have with this product as passing. In other words, as mental events that come up and dissipate.
Stay grounded	Terwijl je dit doet kan het helpen om je bewust te blijven van de situatie waarin	While you are doing this, it can sometimes be helpful to try to remain aware of the situation

	je nu bent, voel je hiervoor bijvoorbeeld je lichaam op de stoel zitten en voel hoe je voeten op de vloer staan	in which you currently are. Try, for example, to feel your body rest on the chair, and feel how your feet are resting on the ground.
Timeframe	Probeer de komende minuut met je gedachten om te gaan zoals je net hebt geleerd tijdens de oefening.	For one minute, try to deal with your thoughts as you were taught during this instruction.

Instruction for immersion towards food-related imagery

part	Original in Dutch	Translation to English
Intro	Straks zal je (opnieuw) een manier om met je gedachtes om te gaan uitgelegd krijgen. Deze manier om met je gedachtes om te gaan zal je dan (opnieuw) toepassen op de gedachtes die je hebt bij jouw opgeschreven voedselproduct. De uitleg over deze manier van met je gedachtes om te gaan zal nu beginnen. Als je op deze manier met je gedachtes omgaat, dan probeer je om helemaal op te gaan in je gedachtes. Om dit te illustreren, zal ik een voorbeeld van een grappige herinnering gebruiken.	We will (again) introduce to you a specific way of dealing with your thoughts. Once we have explained this, you will learn to (again) apply this way of dealing with your thoughts to the thoughts that you have in response to the food product that you wrote down. We will now start introducing this way of dealing with your thoughts to you. If you apply this way of dealing with your thoughts, then you try to completely immerse yourself in your thoughts. To illustrate this, I will use an example of a funny memory
Basic idea	Bijvoorbeeld, als je op straat loopt en aan iets leuks of grappigs terugdenkt, dan begin je vaak spontaan te glimlachen. Het is net of je er echt bent, alsof het nu gebeurt, en alle gedachtes en ervaringen van toen stel je je dan ook heel levendig voor. Ook lichamelijk kan dit heel sterk terugkomen, zoals met die glimlach.	For instance, when walking down the street and remembering something funny, this can instantly make you smile. It is like you are actually there, as if it is happening right now, and you vividly imagine all thoughts and memories of back then. This can also come back in a bodily form, such as with that instant smile.
How to apply it	Hoe kun je dit het beste doen? Probeer je heel levendig de gebeurtenis voor te stellen. Ga hiervoor terug in de tijd en herleef deze ervaring. Denk dus bijvoorbeeld terug aan waar je was, hoe iedereen keek, wat er werd gezegd, wat je dacht, en wat je voelde in je lichaam. Ervaar dus alle emoties, gedachtes, en hoe het voelt in je lichaam, alsof het nu echt gebeurt.	How can you best do this? Try to vividly imagine the event from your memory. To do so, go back in time and relive this experience. Reimagine, for instance, where you were, how everyone looked, what was said, what you thought, and what you felt in your body. In other words, experience all emotions, thoughts, and how it feels in your body, as if it is actually happening right now.
Check	Is het duidelijk wat ik bedoel met deze manier van in je gedachtes opgaan?	Is it clear what I mean with immersing with your thoughts this way this?
Apply to food	Nu zal je wat je hebt geleerd tijdens de oefening gaan toepassen op jouw eigen gedachten. Ik wil je vragen om het voedselproduct die je aan het begin van het onderzoek hebt opgeschreven voor de geest te halen.	Now, during an exercise, you will start applying what you have learned on your own thoughts. I want to ask you to reimagine the food product, the one that you wrote down at the start of the research study.

	Probeer dan helemaal op te gaan in alle gedachten en reacties die jij bij dit product heb, dus stel ze heel levendig voor alsof ze nu echt gebeuren.	Try to immerse yourself in all your thoughts and reactions that you have with your memory. In other words, lively imagine them as if they were happening right now.
Timeframe	Probeer de komende minuut met je gedachten om te gaan zoals je net hebt geleerd tijdens de oefening.	For one minute, try to deal with your thoughts as you were taught during this instruction.