Behaviour Research and Therapy 79 (2016) 23–34

Contents lists available at ScienceDirect

Behaviour Research and Therapy

journal homepage: www.elsevier.com/locate/brat

Enjoying food without caloric cost: The impact of brief mindfulness on laboratory eating outcomes

Joanna J. Arch [a,*], Kirk Warren Brown [b], Robert J. Goodman [b], Matthew D. Della Porta [b], Laura G. Kiken [b], Shanna Tillman [c]

[a] Department of Psychology and Neuroscience, University of Colorado Boulder, 345 UCB Muenzinger, Boulder, CO 80309-0345, USA
[b] Department of Psychology, Virginia Commonwealth University, 806 West Franklin St, Richmond, VA 23284-2018, USA
[c] University of Denver, 2199 South University Blvd, Denver, CO 80208, USA

ARTICLE INFO

Article history:
Received 1 September 2015
Received in revised form
21 December 2015
Accepted 18 February 2016
Available online 22 February 2016

Keywords:
Mindfulness
Eating
Food
Calorie consumption
Weight loss
Eating disorders

ABSTRACT

Objective: Mindfulness-based interventions have been increasingly applied to treat eating-related problems ranging from obesity to eating disorders. Yet few studies have empirically examined the mechanisms of a mindful approach to eating. The current studies examine the potential of brief mindfulness instructions to enhance the psychological and behavioral dimensions of eating.
Methods: In three experiments (total $N = 319$ undergraduates), we examined whether brief mindfulness instructions would enhance the positive sensory experience involved in tasting food as well as healthy eating behaviors.
Results: Relative to distraction control instructions, the first two studies demonstrated that brief mindfulness instructions increased the enjoyment of a commonly pleasurable food (chocolate; Study 1), and a food with generally more mixed associations (raisins; Study 2). The third study replicated and extended these findings to show that brief mindfulness instructions also led to lower calorie consumption of unhealthy food relative to distracted or no-instruction control conditions, an effect mediated by greater eating enjoyment.
Conclusions: Findings demonstrated the power of brief mindfulness instructions to positively impact both health-relevant behavior and sensory experience associated with eating food. Implications for both theory and clinical applications of mindfulness are discussed.
© 2016 Elsevier Ltd. All rights reserved.

Mindfulness-based interventions have been increasingly employed to address eating-related problems ranging from eating disorders to obesity, and show initial promise across multiple of these areas (O'Reilly, Cook, Spruijt-Metz, & Black, 2014; Wanden-Berghe, Sanz-Valero, & Wanden-Berghe, 2010). Yet comparatively little work has examined the more fundamental mechanisms of mindfulness-based approaches to eating. Investigating potential mechanisms has the potential to elucidate the pathways by which mindfulness-based approaches influence how people enjoy and consume food and counter clinical problems related to eating. The current set of studies were undertaken to address this important gap.

In addition, theory and considerable research indicate that mindfulness promotes well-being (see Brown, Ryan, & Creswell, 2007) but much of this work has been directed towards investigating whether mindfulness ameliorates negative or maladaptive psychological experiences (e.g., Frewen, Evans, Maraj, Dozois, & Partridge, 2008; Hofmann, Sawyer, Witt, & Oh, 2010), rather than whether mindfulness promotes positive experiences (see Arch & Landy, 2015). The present studies thus were specifically designed to examine whether mindfulness fosters positive psychological experience of eating - an activity that is often poorly attended to, yet offers rich potential for daily enjoyment.

Researchers (Brown & Ryan, 2003; Kiken & Shook, 2011) have proposed that mindfulness may promote higher quality moment-to-moment experiences for several reasons. For example, the receptive attention that characterizes mindfulness may promote more openness to explore experiences, including pleasant features that might otherwise go unnoticed, and to enhance awareness of

* Corresponding author.
E-mail addresses: Joanna.Arch@Colorado.edu (J.J. Arch), kwbrown@vcu.edu (K.W. Brown), goodman.rob@gmail.com (R.J. Goodman), matthewdellaporta@gmail.com (M. D. Della Porta), kiken@kent.edu (L.G. Kiken), drshannatillman@gmail.com (S. Tillman).

http://dx.doi.org/10.1016/j.brat.2016.02.002
0005-7967/© 2016 Elsevier Ltd. All rights reserved.

sensory perceptions (Brown et al., 2007). Moreover, the emotional benefits of mindfulness, including the containment and down-regulation of negative emotional responses (Arch & Craske, 2006; see Arch & Landy, 2015), and less negative affect in general (Brown & Ryan, 2003), may create more opportunities for experiencing positive states of mind.

Outside the context of eating, limited evidence supports the link between mindfulness and positive experiences. Experience sampling research (Brown & Ryan, 2003) has shown that state, or momentary mindfulness is associated with more intense and frequent pleasant affect. Experimental research (Erisman & Roemer, 2010) demonstrated that a very brief mindfulness training, or induction, enhanced positive affect in response to a positive film clip, relative to a neutral control condition. Kiken and Shook (2011) found that participants induced into mindful states identified the valence of positive stimuli more accurately than controls. Further, Garland, Gaylord, and Fredrickson (2011) found that increases in trait mindfulness over the course of a mindfulness-based intervention were related to increases in self-reported positive reappraisals (i.e., reframing events as meaningful or beneficial). Attending to present-moment experience is also central to savoring – enjoying and increasing one's positive emotional experiences (Bryant, 1989) - which in turn has been related to higher positive affect (Bryant, 2003; Quoidbach, Berry, Hansenne, & Mikolajczak, 2010). These studies provide initial evidence that mindfulness promotes positive emotional experiences. Studies on this topic are few, however, particularly investigating the potential for mindfulness to enhance mundane sensory experiences such as tasting food.

Thus, the current studies were designed first to test whether brief mindfulness instructions[1] enhanced the sensory experience of eating food, among university students. In the first two experiments reported here, we explored the effect of mindfully tasting foods with generally positive associations (chocolate; Study 1) and more neutral or mixed associations (raisins; Study 2). To distinguish mindful eating from the distracted approach to eating that is common in modern societies (see Robinson et al., 2013; Wansink, 2004), we compared the effects of eating mindfully with those of eating distractedly. In that eating in a distracted manner represents how many people often eat - for example, while talking with others, watching television, reading, texting, and so on – we conceptualized it as the control condition. Based on mindfulness theory (Brown & Ryan, 2003; Kristeller & Wolever, 2010) and the preliminary evidence reviewed here, we predicted that induced mindfulness would enhance the positivity of the ordinary sensory experience of eating, measured both in terms of greater enjoyment (hypothesis 1) and in a greater desire to continue the sensory experience of eating (hypothesis 2). Based upon previous findings on both mindfulness and savoring, we also predicted that mindfulness would result in greater positive and lower negative affect following food consumption (hypothesis 3).

If mindfulness enhances eating enjoyment and a desire to continue eating, as we predict, then it may lead to eating more – a potentially undesirable consequence, particularly if the foods eaten are calorie-rich or have poor nutritional value (e.g., snacks with high fat, salt, or sugar content). Yet it has been suggested that mindfulness enhances awareness of and responsiveness to satiety cues, and therefore, functions adaptively to reduce calorie consumption (Kristeller & Wolever, 2010). Consistent with this calorie consumption hypothesis, Jordan, Wang, Donatoni, and Meier (2014) found that trait and state (induced) mindfulness predicted lower calorie intake; however the results were not differentiated by the healthfulness of the available foods (candy, pretzels, and almonds). Self-reported trait mindfulness was related to more healthy food choices (selecting fruit over sweets as a "thank-you" gift at the end of the study), a relation mediated by self-reported preferences for healthy over unhealthy foods.

Building upon this preliminary evidence, the third experiment (Study 3) examined whether briefly instructed (induced) mindfulness leads to lower calorie consumption of unhealthy (high sugar, salt or saturated fat) snack foods, in addition to increased enjoyment of, and desire to continue tasting food. Based on mindful eating theory (Kristeller & Wolever, 2010) and initial evidence reported here, we hypothesized that mindfulness, relative to distraction and to no-instruction control conditions, would lead to lower food consumption, particularly of the unhealthy sort (hypothesis 4). We also examined whether the enjoyment of tasting experiences helped to mediate the predicted relationship between (briefly) induced mindfulness and calorie consumption (hypothesis 5). As a whole, these studies examined in a laboratory context whether brief mindfulness offers both psychological and physical benefits by enhancing the positive experience of eating while simultaneously decreasing caloric consumption.

1. Study-1

An initial experiment was conducted using chocolate to test the first three hypotheses: that relative to distracted attention, mindful attention would enhance food enjoyment (hypothesis 1) and the desire to continue eating (hypothesis 2), and would result in greater positive affect and less negative affect following tasting (hypothesis 3).

2. Method

2.1. Participants

Participants were recruited from the undergraduate psychology research pool of a large Mid-Atlantic U.S. university and earned course credit for participation. Inclusion criteria included age (18 years or older) and fluency in English. Exclusion criteria included an allergy to, strong dislike of, or diet that excluded eating chocolate, a history of diabetes, a current illness that affected taste, or cigarette smoking, which can blunt the sense of taste. Criteria were assessed upon arrival to the laboratory with a screening questionnaire.[2]

Eighty-one participants (59.3% female) met the inclusion criteria and completed the study. Participants were on average 19.49 years old ($SD = 1.80$, range 18–26). Participants were White/Caucasian (56.8%), African-American (23.5%), Asian-American (12.3%), Hispanic/Latino(a) (4.9%), and Native American (2.5%).

2.2. Procedure

The study was titled "Concentration and Food Tasting Study" that would "examine the effect of tasting on mental concentration." Participants completed a single experimental session in a group computer laboratory with 8 individual cubicles. A sole male experimenter administered all sessions. The experimenter left the room after training to reduce experimental demands on the participants.

After giving informed consent, participants completed the

[1] Thus, we assessed the effects of briefly instructing or training participants to eat food mindfully, as opposed to training them in formal mindfulness meditation.

[2] The chocolate-related questions were embedded in questions about a variety of foods so that participants would not know beforehand what they would taste.

eligibility screening questionnaire. Eligible participants then completed baseline questionnaires via computer (see *Measures*). Next, the experimenter led a brief condition-specific training in how to approach the tasting trials (see *Experimental conditions*). Each participant was then given a word puzzle and five chocolate chips for the tasting trials with strict instructions to taste only one chip per trial. Participants were then guided by computer-mediated visual and auditory instructions through five tasting trials. Water was available in each cubicle to drink between tasting trials. Following the trials, participants completed a manipulation check and post-tasting questionnaires on the computer. Participants were then debriefed, thanked, and dismissed.

2.3. Experimental conditions

Participants were randomly assigned at the session (group) level to a mindfulness condition ($n = 46$) or a distraction control condition ($n = 35$), using randomizing software. In presenting the conditions to participants, mindfulness was referred to as "sensing" and distraction was referred to as "focusing" (on the word puzzle, see below) in order to mask study intentions and minimize social desirability effects. Participants were run in groups ranging in size from 1 to 8. The experimenter was blind to study condition until immediately before the tasting trials. Brief (single paragraph), condition-specific instructions were repeated visually and aurally (via headphones) on each participant's computer at regular intervals before and between the tasting trials.

2.3.1. Mindfulness condition

The instructions for this condition were adapted from the raisin-eating exercise used by Kabat-Zinn (1990). The aim of the mindfulness condition was to direct participants' attention as fully as possible towards the sensory experience of eating. Participants were told: "While you are eating the chocolate, it is very important that you focus your attention on the sensory experience of tasting the chocolate. Focus on the various sensations you experience such as the color, texture, scent, and flavor while tasting and fill your head with the details of these sensations …" They were also instructed to work on a hidden word puzzle between tasting trials as a means of taking task breaks. To check for understanding, a randomly selected participant was asked to repeat the instructions for the group.

2.3.2. Distraction control condition

This condition was designed to mimic eating in everyday student life, in which eating while engaging in other activities (e.g., reading, texting, consuming media, talking) is typical. Participants were instructed: "While you are eating the chocolate, it is very important that you focus your attention on the hidden word puzzle. You will also do this during the breaks between tasting trials. Focus on finding as many hidden words as you can and circle each word as you find it." Again, a participant was asked to repeat the instructions to ensure the groups' understanding. The distraction control condition matched the mindfulness condition on attentional demand, engagement, and credibility. The word puzzle focus allowed us to measure engagement in this condition relative to the mindfulness condition, operationalized as number of words found.

2.4. Measures

2.4.1. Baseline measures

The well-validated *Positive and Negative Affect Schedule* (PANAS; Watson, Clark, & Tellegen, 1988) provided measures of state, or current, positive affect (10 items; sample $\alpha = .85$) and negative affect (10 items; sample $\alpha = .84$). In addition, a single-item hunger rating asked participants to "Please indicate how hungry you are at this moment" using a 1 to 5 Likert scale ranging from "very hungry and not at all full (1)" to "completely full and not at all hungry" (5).

2.4.2. Taste trial measures

After eating each of 5 chocolate chips, participants were asked to rate their tasting experience on two dimensions: enjoyment and desire to eat another chocolate chip. For the *enjoyment ratings*, participants were asked: "Using any number between 1 (*hated it*) and 10 (*loved it*), please indicate how much you enjoyed tasting the chocolate." Single number response values were typed using the computer keyboard. Following each the 5 enjoyment ratings, participants were asked to make a *desire rating* as follows: "Using any number between 1 (*I absolutely DO NOT want another taste*) and 10 (*I absolutely DO want another taste*), please indicate how much you would like another chocolate." Again, single values were typed using the computer keyboard.

2.4.3. Post-tasting measures

Following the taste trials, participants again completed the PANAS as an assessment of state ("right now") positive and negative affect. They also completed the 5-item Interest/Enjoyment subscale of the *Intrinsic Motivation Inventory* (IMI; e.g., Deci, Eghrari, Patrick, & Leone, 1994) to assess level of interest in and enjoyment of the study tasks (sample $\alpha = .71$). Responses were made on a 7-point Likert scale ranging from 1 (*not at all true*) to 7 (*very true*).

2.4.4. Manipulation checks

A neutral-content *word search puzzle* was completed by participants in both conditions. Aside from providing the main task for the distraction control condition participants, the number of words found in the puzzle served as a manipulation check such that those in the distraction condition were expected to find significantly more words, on average, than those in the mindfulness condition (who worked on the puzzle only between tasting trials). A second check on the effectiveness of the attention manipulation was made with 4 self-report items; 2 items assessed sensory focus on the taste experience: "I observed the tasting experience closely" and "I paid close attention to the physical sensations caused by the tasting experience." Two items assessed focus on the word search puzzle: "I tried to stay focused on the word puzzle, not the tasting experience." and "I concentrated on things related to the word puzzle rather than the tasting experience." Responses were made on a 7-point scale from 1 (*never did that*) to 7 (*always did that*). Each set of two items showed high internal consistency (αs = .80 and .84, respectively), so responses to the two items in each set were averaged to form two scores: sensory experience compliance and puzzle compliance.[3]

2.5. Statistical analyses

To analyze the enjoyment and desire ratings, we used a restricted maximum likelihood (REML) mixed modeling approach (e.g., Bryk & Raudenbush, 1992; de Leeuw & Kreft, 2011) in the MIXED procedure in SAS (Institute, 1992, 1997). In these models, the primary interest was on the main effect of condition and the condition × time interaction while permitting control of relevant categorical and continuous demographic and psychological variables. Intrinsic motivation was covaried in each model due to its anticipated relation to enjoyment and desire ratings. Hunger was

[3] Due to a procedural error, 66/81 participants completed this measure.

covaried in preliminary models.[4]

To enhance interpretability of the mixed model intercept, predictor variables were grand-mean centered around zero (continuous variables) or re-scaled to include zero (categorical variables) (Bryk & Raudenbush, 1992). Level 2 variables were treated as fixed effects whereas the level 1 time variable was treated as random (as was the intercept and slope for each participant). The "between/within" method for computing denominator degrees of freedom was used in all models. Choice of most appropriate within-person error covariance structure (unstructured, compound symmetry, or first-order autoregressive) was determined through χ^2 tests comparing the -2RLL model fit indices for each outcome (as well as significance of autoregression). Unstructured covariance structures were used in all models. Effect size estimates were calculated using Cohen's *d* (Cohen, 1988) using methods specified by Feingold (2009). Preliminary REML unconditional means models showed significant between-person variation (individual differences in average values of each outcome) and within-person variation (variations across time within-persons) on all outcomes ($ps < .0001$), supporting the investigation of condition effects over time.

Using SAS GLM, ANOVA models assessed the manipulation checks and the effect of experimental condition on change in state positive and negative PANAS affect scores. All continuous predictor variables were centered before analyses (Aiken & West, 1991). Homogeneity of variance and variance differences were checked in all analyses, and the Huynh-Feldt epsilon correction was applied where indicated. Effect size estimates were calculated using partial eta squared.

3. Results and discussion

3.1. Experimental manipulation checks

Consistent with a successful manipulation of condition, mindfulness condition participants reported higher compliance with the mindfulness instructions ($M = 5.74$; $SD = 1.21$) than those in the distraction control condition ($M = 4.38$; $SD = 1.37$), $F(1, 64) = 18.28$, $p = .0001$, $\eta_p^2 = .22$, whereas those in the distraction condition reported higher compliance with the word puzzle (distraction) instructions ($M = 5.18$; $SD = 1.23$) than participants in the mindfulness condition ($M = 3.63$; $SD = 1.79$), $F(1, 64) = 15.53$, $p = .0002$, $\eta_p^2 = .20$. Further, participants in the distraction control condition found significantly more puzzle words ($M = 26.00$, $SD = 8.20$) than those in the mindfulness condition ($M = 20.01$, $SD = 6.07$), $F(1, 133) = 23.18$, $p < .001$, $\eta_p^2 = .15$. These results suggested that the manipulation was effective.

3.2. Condition effects on enjoyment and desire ratings

The effect of experimental condition and intrinsic motivation did not interact with time so these interaction terms were removed from the models but were retained as main effects (intercept terms). Preliminary multilevel models also showed that gender did not predict enjoyment or desire ratings ($ps > .19$) so it was excluded from final models. In the multilevel model predicting enjoyment ratings over time, condition showed a main effect, $t(78) = 2.62$, $p = .01$, $d = .51$, such that those in the mindfulness condition reported higher enjoyment of the chocolate than those in the distraction control condition (see Fig. 1a). In predicting desire to continue tasting, condition showed a marginal main effect, $t(78) = 1.94$, $p = .056$, $d = .38$, such that those in the mindfulness condition reported higher desire to continue tasting ratings than those in the distraction control condition. The pattern of group differences, as presented in Fig. 1b, also suggests a steeper decline in desire to taste chocolate over time for mindfulness relative to distraction control.

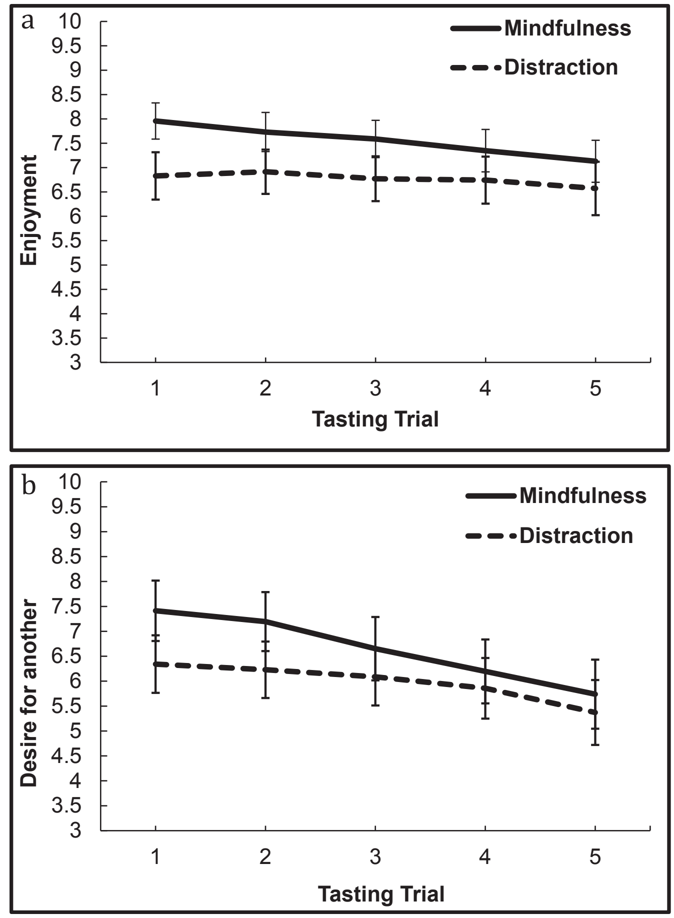

Fig. 1. a. Enjoyment ratings across Study 1 chocolate tasting trials by condition (Mean ± 1 SE; p = .01). b. Desire for another ratings across Study 1 tasting trials by condition (Mean ± 1 SE; p = .06).

Higher intrinsic motivation for the task also showed a main effect in predicting both higher enjoyment ratings, $t[78] = 2.56$, $p = .01$, $d = .51$, and greater desire to continue tasting, $t[78] = 3.23$, $p = .002$, $d = .49$, across time. Finally, there were main effects of time such that enjoyment and desire to continue tasting ratings decreased over time across both the mindfulness and distraction conditions, $t(323) = -2.51$, $p = .01$, $d = -.33$ and $t(323) = -4.60$, $p < .0001$, $d = -.64$, respectively.

3.3. Condition effects on changes in affective state

Repeated measures ANOVAs tested condition differences in state positive and negative affect scores from pre-to post-tasting task. Negative affect decreased from pre-to post-tasting trials (pre $M = 15.30$; $SD = 9.90$; post $M = 11.85$, $SD = 7.80$; $F[1, 78] = 12.00$, $p < .0009$, $\eta_p^2 = .13$), whereas positive affect did not change significantly, $p = .59$. Intrinsic motivation ($ps > .32$), condition ($ps > .65$), and the interaction of condition × time ($ps > .72$) each failed to predict negative or positive affect.

The results of Study 1 partially supported the first two

[4] In none of the food rating or affect models was hunger a significant predictor, either as a main effect ($ps > .58$) or in interaction with time ($ps > .06$). Thus, we excluded hunger from final models.

hypotheses by showing that a mindful state produced a significantly greater sense of enjoyment of a positively-valenced food (chocolate) and marginally greater desire to continue the tasting experience; both effect sizes were moderate (Cohen, 1988). Our third hypothesis was not supported in that induced mindfulness did not predict changes in affective state from pre-to post-tasting. Rather, across both conditions, negative affect decreased over this period.

4. Study 2

Study 2 was undertaken to replicate and extend the findings of Study 1, and in particular to address their generalizability to another food, and to determine whether more detailed, experiential, and individualized mindfulness instructions might more strongly influence the sensory and affective dimensions of eating. Generalizability was sought by having participants taste a food with more varied (i.e. less uniformly positive) associations, namely, raisins. Training in mindfulness or distraction was more experiential (e.g., included practice in eating a raisin according to condition instructions) to increase the power of the induction. To eliminate potential confounds of group randomization from Study 1 (e.g., friends participating together), Study 2 participants were randomized and completed the procedure individually.

5. Method

5.1. Participants

Participants ($N = 136$; 76.5% female) were recruited from a large Western U.S. university and met the same criteria for study entry as in Study 1. Participants were on average 20.1 years old ($SD = 2.4$, range 18–35), with family incomes averaging $60–70K/year. Of the participants, 39.7% identified as East Asian, 34.6% as White/Caucasian, 17.6% as South Asian, 11.0% as Hispanic/Latino(a), and 2.2% as Black/African-American; seven participants indicated more than one race or ethnicity.

5.2. Procedure

The procedure followed that of Study 1 with several exceptions: Raisins were used as the stimulus material rather than chocolate chips. Participants completed the study individually under the supervision of one of four female experimenters rather than in groups. Finally, the condition instructions were more extensive, detailed, and experiential in nature (see *Experimental Conditions*, below). Provision of training and a detailed manual were designed to enhance uniformity of instructional presentation across experimenters. Thus, following individual training, each participant was given a word puzzle and five raisins for the tasting trials with strict instructions to taste only one raisin per trial. Participants were then guided by computer-mediated visual and auditory instructions through five raisin tasting trials.

5.3. Experimental conditions

Participants were randomly assigned to the mindfulness ($n = 68$) or distraction control ($n = 68$) condition using a random number generator. Immediately after viewing a given participant's random assignment, the experimenter gave 5–7 min of standardized training for the assigned condition (e.g., a full single-space page of training instructions), which included opportunities for participants to ask questions.

5.3.1. Mindfulness condition

Participants were told that they would learn “a technique called sensing,” which involves “paying close attention to your current experience with as much openness and sensitivity to its details as possible.” Following further descriptions of “sensing”, participants practiced eating one raisin slowly using this approach and were coached throughout this practice to fully engage all of their senses in the tasting experience. They also were reminded that “this may feel new and different … if you feel impatient or start to get carried away in thoughts about this exercise, simply notice that and gently return your attention to the raisin itself … re-immerse yourself in the experience of eating.” As in Study 1, they were instructed to work on a hidden word puzzle between tasting trials (to facilitate task breaks).

5.3.2. Distraction control condition

Participants were told that they would learn “a technique called focusing” that would allow them to complete a word puzzle as quickly and accurately as possible and not be distracted by eating raisins. Instructions stated: “When you approach your experience in a focusing state of mind, you try to block out distractions and focus only on what needs to get done … For example, when you're reading something for a class, sometimes you have to send a text message or eat lunch, and continue your class readings at the same time … The ability to maintain that kind of focused attention on your reading while doing something else at the same time is something you are going to use today.” After further instructions, they practiced focusing on the neutral-content word puzzle while eating a raisin.

5.4. Measures

All measures used in Study 1 were also used in this study, including baseline measures of the PANAS (Watson et al., 1988) and single-item hunger scale, tasting trial measures of enjoyment and the desire to eat another raisin, post-tasting measures of the PANAS and IMI scales (Deci et al., 1994), and manipulation checks of the number of found words in the word puzzle and the study-specific, 4-item measure. The positive and negative affect subscales of the PANAS showed high internal consistency (sample $\alpha = .87$ and .83, respectively at pre-test), as did the IMI (sample $\alpha = .72$).

5.5. Statistical analyses

Similar to Study 1, analyses with more than two measurement points (enjoyment and desire ratings) were conducted using multilevel linear models in HLM 6.0 (Raudenbush, Bryk, & Congdon, 2004). Level of hunger and intrinsic motivation (IMI) were covaried. ANOVAs run in SPSS 18.0 were used to check manipulation effectiveness and to examine affect (PANAS) outcomes.

6. Results and discussion

6.1. Condition manipulation checks

As in Study 1, participants in the mindfulness condition reported higher compliance with the sensory experience instructions ($M = 6.02$, $SD = .74$) than those in the distraction control condition ($M = 3.83$, $SD = 1.49$), $F(1, 134) = 118.13$, $p < .001$, $\eta_p^2 = .47$, whereas those in the distraction condition reported higher compliance with the word puzzle instructions ($M = 5.57$, $SD = .92$) than participants in the mindfulness condition ($M = 2.88$, $SD = 1.57$), $F(1, 134) = 149.51$, $p < .001$, $\eta_p^2 = .53$. Distraction control participants also found significantly more words ($M = 30.25$, $SD = 9.33$) than mindfulness participants ($M = 20.09$, $SD = 6.20$), $F(1, 133) = 55.40$, $p < .001$, $\eta_p^2 = .29$ Together, these findings indicate that the manipulation was effective.

6.2. Effects on enjoyment and desire ratings

As in Study 1, in the models predicting enjoyment and desire ratings, we found that the level 2 predictors (condition, hunger, motivation) did not show significant interaction effects with time (slopes) and thus were retained in the models for main effects only (intercept). In the multilevel model predicting enjoyment ratings over time, condition showed a marginally significant main effect, $t(133) = 1.86$, $p = .07$, $d = .27$, such that mindfulness resulted in higher enjoyment ratings than distraction control (see Fig. 2a). Intrinsic motivation showed a significant main effect, with higher scores predicting higher enjoyment ratings, $t(133) = 4.96$, $p < .001$, $d = .33$, whereas the main effect of hunger was non-significant, $p = .24$, $d =$ - .09. Enjoyment ratings diminished over time across both groups, $t(135) = -3.75$, $p < .001$, $d = -.32$.

For desire ratings, condition showed a significant main effect, $t(132) = 2.72$, $p = .008$, $d = .39$, demonstrating that mindfulness led to a greater desire to continue the tasting experience than distraction (see Fig. 2b). Higher intrinsic motivation and greater hunger also predicted higher desire to continue tasting, $t(132) = 5.88$, $p < .001$, $d = .34$, and, $t(132) = -2.56$, $p = .01$, $d = 19$, respectively. Desire to continue eating diminished over time in both conditions, $t(135) = -7.03$, $p < .001$, $d = -.64$.

6.3. Effects on changes in affective state

Multivariate repeated measure ANOVAs were used to examine the main effect of time and the condition × time interaction on pre-to post-tasting changes on state positive and negative PANAS scores. There were large main effects of time for positive affect, $F(1, 134) = 171.15$, $p < .001$, $\eta_p^2 = .56$, and negative affect, $F(1, 134) = 54.40$, $p < .001$, $\eta_p^2 = .29$, indicating that positive affect decreased and negative affect increased from pre-to post-tasting trials. The condition × time interaction for negative affect (but not positive affect) was significant such that the mindfulness participants (pre $M = 18.49$, $SD = 7.87$; post $M = 26.43$, $SD = 5.87$) reported smaller increases in negative affect than distraction participants (pre $M = 16.88$, $SD = 6.17$; post $M = 28.52$, $SD = 5.62$), $F(1, 134) = 17.40$, $p < .001$, $\eta_p^2 = .12$.

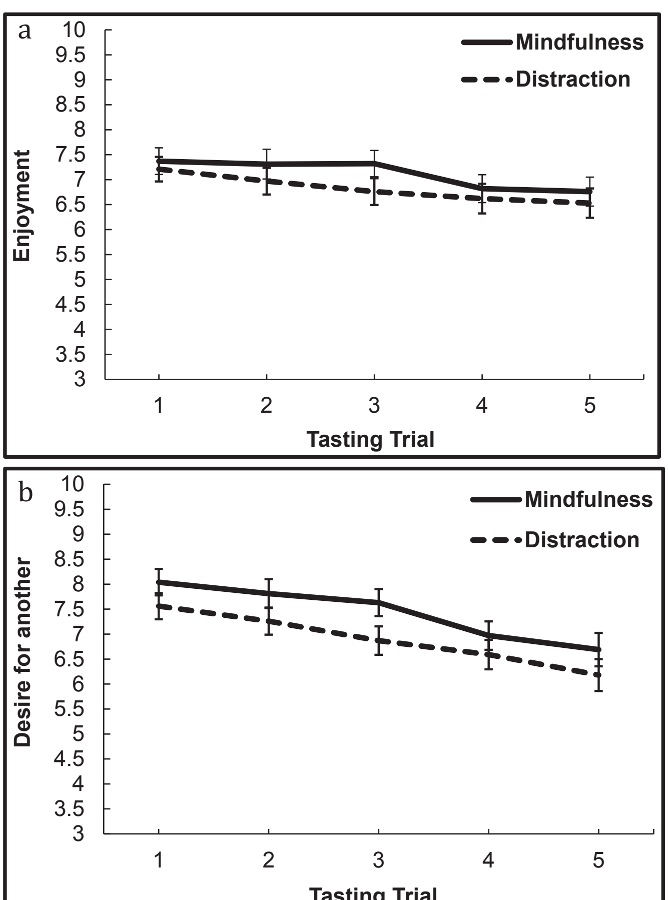

Fig. 2. a. Enjoyment ratings across Study 2 raisin tasting trials by condition (Mean ± 1 SE; p = .07). b. Desire for another ratings across Study 2 tasting trials by condition (Mean ± 1 SE; p < .01).

To summarize, Study 2 largely supported the first three hypotheses, showing that the experiential benefits of mindfulness (versus distraction) generalized to a food with more mixed (i.e. less uniformly positive) associations on dimensions of enjoyment and desire to continue eating. Although participants experienced Study 2 more negatively than Study 1, perhaps due to the isolation of the setting (e.g., the fact that participants were run alone rather than in groups) the benefits of mindfulness extended to state affect, resulting in smaller increases in negative affect from pre-to post-tasting relative to distraction.

7. Study 3

If a mindful state enhances enjoyment of eating and an initial desire to eat more, as Study 1 and Study 2 showed, does it encourage more food intake? While a reasonable supposition, theory and initial empirical evidence (Jordan, Wang, Donatoni, & Meier, 2014; Timmerman & Brown, 2012) indicate that mindfulness is associated with lower calorie consumption, and may be associated with more healthy food choices. Study 3 was designed to test these propositions experimentally.

In accordance with hypothesis 4, we predicated that brief mindfulness instructions would lead to lower calorie consumption, especially of "junk foods" (high sugar, salt, or saturated fat snack foods). Thus, to examine the generalizability of the relation between mindfulness and eating behavior, healthy and "junk food" snacks were available for consumption in two different contexts: during a free choice eating period and during a taste rating task. Assessing eating behaviors across these two contexts allowed us to determine whether mindful states influenced eating behaviors to a greater extent within a free-choice eating context (when they had a choice whether to eat, and were simply asked to eat something "so that they weren't starving") or within more sensory-focused eating contexts (when they were asked to eat some of each food in order to rate them along different taste dimensions, such as sweet, salty, etc., but could choose how much to taste, see *Methods*). These two contexts resemble real-world situations in which eating is, respectively, optional or expected (as a dinner guest, for example).

We also examined whether higher enjoyment helped to explain, or mediate, the anticipated lower calorie consumption among mindfulness participants, per hypothesis 5. It seems like a reasonable lay belief that food enjoyment leads to higher food consumption, but we anticipated that mindful eating would foster savoring of the gustatory experience, which past research suggests may lead to lower consumption (Rozin, Kabnick, Pete, Fischler, & Shields, 2003). In addition, Study 3 sought to replicate the enjoyment and desire findings of Study 2, as well as the positive and negative state affect findings.

Finally, Study 3 introduced a third, no-instruction control condition to better test the claim that condition differences on the enjoyment, desire, and calorie intake outcomes are due to the positive effect of mindfulness rather than the deleterious effect of distraction. If this claim is correct, distraction and no-instruction conditions should both show differences from the mindfulness condition on the outcomes in hypothesized directions. We did not predict differences between the distraction and no-instruction control conditions. Previous eating studies have demonstrated greater caloric consumption for distracted relative to non-distracted (but not mindful) eating contexts (Robinson et al., 2013). However, given the prevalence of mind-wandering and distraction in daily life (Killingsworth & Gilbert, 2010; Mooneyham & Schooler, 2013), non-instructed eating outcomes might actually resemble those of distracted eating.

8. Method

8.1. Participants

One hundred and two undergraduate students at a large Mid-Atlantic university participated, with an average age of 20.78 years (SD = 3.87, range = 18–37 years). The sample included 59 (57.84%) males. In terms of race/ethnicity, 49 (48.04%) identified as African-American, 28 (27.45%) as Hispanic/Latino, 10 (9.80%) as Caucasian, 2 as biracial (1.96%), and 1 each as Asian-American or Native-American (<1% each).

8.2. Procedure

From the beginning of the study session through the raisin tasting task, Study 3 procedures were identical to those of Study 2, with the exception of randomization to 3 rather than 2 conditions for the raising tasting task (see *Experimental Conditions*, below). Additionally, we requested that participants fast for 2 h prior to the study so that they would be sufficiently hungry to want to taste the offered foods. The study procedures were pilot-tested and refined prior to the start of the study in response to participant feedback.

8.2.1. Free eating period

Following the raisin tasting trials, participants were asked to complete the same post-tasting measures as in Studies 1 and 2. Upon entry to the subject room with the measures, the experimenter also set on a table in front of each participant a tray bearing six unpackaged foods, each in a separate 6 oz ramekin, that provided a choice of sweet (M&M's®, Reese's Pieces®), salty (Lay's Potato Chips®, Rold Gold Pretzels®), high saturated fat (Lay's Potato Chips®, M&M's®, Reese's Pieces®), and healthy (defined as low sugar and low salt; unsalted almonds, carrot sticks) snack choices. The experimenter said: “While I get the next part of the study ready, we ask you to please complete a few questionnaires. We also want to offer you some food because we know you had to fast beforehand so that you had a clear palate for tasting. Please try to eat something so that you're not starving. I'll be back in about 5 min” After 5 min, the experimenter returned to “refresh the food tray for the next part of the study” and encouraged the participant to relax and read neutral-content magazines provided on a nearby table. The experimenter weighed each food amount in a separate room to measure the amounts eaten, replenished the food bowls, and reweighed the replenished food amounts in preparation for the food rating task.

8.2.2. Food rating task

Upon return with the food tray, the experimenter said to each participant, “Now please eat some of each food and rate the foods on this sheet (pointing to a rating sheet). Please taste the food in the same manner you were instructed in before …” and then gave condition-specific reminders of how to taste the food (see *Experimental Conditions*, below). At the top of the food rating worksheet (see *Measures*), participants were instructed to “Please eat as much of each food as is needed to make an accurate rating along each [food rating] dimension”.

Following the food rating task, the bowls were removed and reweighed to determine the amount eaten. Calories consumed here and during the free eating period were computed by multiplying the number of ounces consumed of each food by the number of calories per ounce for that food. Participants were then debriefed on the study purpose and dismissed.

8.3. Experimental conditions

Participants were randomly assigned to mindfulness ($n = 33$), distraction control ($n = 33$) or no-instruction control ($n = 36$) conditions using randomizing software.

8.3.1. Mindfulness and distraction control conditions

For the raisin tasting trials, the content of the mindfulness and distraction control condition instructions matched those in Study 2 but were administered via audiorecording immediately prior to the tasting trials (instead of by the experimenter) to maximize standardization. To set the tone for the audiorecordings, participants in both the mindfulness and distraction control conditions were told, “Now please listen very carefully to what you will concentrate on during the raisin tastings. We ask that you pay close attention to what is being said during the recordings. The audio recordings are not trying to trick you in any way, and there is no need to try to memorize what is being said during them. You will not be tested on anything that is said during the audio recordings. Just be comfortable, relax, and listen. At times you may feel weird or awkward while listening to the recordings. This is completely normal.” Mindfulness participants were further told, “We ask that you sit up straight in your chair, gently rest your hands in your lap, and make your best effort to give your full attention to the recording, to be fully engaged in anything it may ask you to do or think about.” Later, at the start of the food rating task, the experimenter asked participants to “please taste the food in the same manner you were instructed in before …”. Mindfulness participants then were told, “that is, please carefully and slowly take in the taste, texture, and full moment-by-moment experience of eating the food” whereas distraction control participants then were told, “that is, please continue to work on the word puzzles while you eat the food.”

8.3.2. No instruction control condition

To match the mindfulness and distraction control participants on time and attention spent listening to the condition-specific recordings prior to the tasting trials, no-instruction participants listened to a excerpt from an engaging cognitive psychology textbook used in a previous study (Arch et al., 2014). The introduction to this engaging excerpt matched the common instructions given to all conditions for this task, e.g., “We ask that you pay attention to what is being said during the recording. The audio recording is not trying to trick you in any way, and there is no need to try to memorize what is being said during them. You will not be tested on anything that is said during the audio recordings. Just be comfortable, relax, and listen. At times you may feel weird or awkward while listening to the recordings. This is completely normal.” For the raising tasting trials, participants in the no-instruction control condition were given only the basic task instructions common to all conditions (e.g., “please eat just one raisin at a time as the computer program instructs you, and make ratings when prompted to do so”). After the tasting trials, the no-instruction control condition completed the rest of the study in the same manner as the other conditions, minus the mindfulness- and distraction-specific instructions.

8.4. Measures

Most measures used in Studies 1 and 2 were also used in this study,[5] with the addition of the PANAS-X attentiveness scale (Watson & Clark, 1994) as a manipulation check for adherence with the mindfulness instructions. In addition, we developed a worksheet with three questions for the food rating task, which asked participants to rate each of the six foods on an 8-point Likert scale (with 5 anchors, including 0 = not at all to 7 = extremely): How sweet does this food taste to you?; How salty does this food taste to you?; and How much do you enjoy eating this food?

9. Results and discussion

9.1. Condition manipulation check

To assess whether those in the distraction control condition found more words in the puzzle than those in the mindfulness and control conditions, *t*-tests compared the number of found words by condition. Distraction control participants found significantly more words ($M = 36.70$, $SD = 10.76$) than mindfulness participants ($M = 22.91$, $SD = 8.01$), $t\,(59.14) = 5.91$, $p < .001$, and no-instruction control participants ($M = 25.33$, $SD = 13.11$), $t\,(67) = 3.95$, $p < .001$. As expected, the mindfulness and no-instruction control conditions did not differ from one another, $t\,(58.67) = .94$, $p = .35$. These results indicate that the word search manipulation of distraction was effective.

We also examined changes in the attentiveness PANAS scales (from baseline to post-raisin tasting trials and post-food rating task) as a manipulation check for adherence with the mindfulness instructions. The mindfulness condition showed significant increases in attentiveness over time relative to the control conditions, $b = .28$, $p = .04$, $d = .12$, whereas the control conditions did not differ from one another, $b = -.17$, $p = .55$, $d = -.07$, suggesting that the mindfulness manipulation successfully increased attentiveness.

9.2. Effects on the number of calories consumed

To assess caloric intake in the 4 food categories, we totaled the combined M&Ms and Reese's Pieces ("sweet foods") calories consumed across both the free-eating period and food rating task, as well as the combined potato chip and pretzels across the free-eating and food rating periods ("salty foods"), and the combined M&Ms, Reese's Pieces, and potato chip calories across both periods to compute "high saturated fat foods" calories. This last category overlapped with the previous two categories, but given the historical focus on the deleterious effects of saturated fat consumption, we believed it important to investigate as a distinct category. We combined carrots and almonds to compute total "healthy foods" calories consumed. Finally, we computed total calories consumed across the 6 food types.

Table 1a presents the number of calories consumed in each food category by condition. Hierarchical regression models conducted in SPSS 23.0 software entered hunger and intrinsic motivation (IMI) in step 1, and experimental condition in step 2. Participants in the mindfulness condition consumed fewer sweet food calories than those in the two control conditions, $b = -12.66$, $p < .01$, $\Delta R^2 = .07$; the control conditions did not differ from one another in sweet food calorie intake, $b = -.39$, $p = .96$. Those in the mindfulness condition consumed fewer salty food calories than those in the control conditions, $b = -8.99$, $p < .05$ [.048], $\Delta R^2 = .04$; the control conditions did not differ in salty food calorie intake, $b = 5.10$, $p = .50$. Mindfulness participants also consumed significantly fewer high saturated fat calories than those in the control conditions, $b = -15.61$, $p = .02$, $\Delta R^2 = .05$, whereas the control conditions did not differ from one another in calories consumed, $b = 3.38$, $p = .76$. The mindfulness and control conditions did not differ on healthy food calories consumed, $b = -.03$, $p = .99$, $\Delta R^2 = .00$, nor did the control conditions differ from one another on this outcome, $b = -3.82$, $p = .66$. In sum, consistent with our fourth hypothesis, those in the mindfulness condition consumed fewer "junk food" calories than those in the control conditions and did not compensate by consuming extra "health food" calories. Across all foods, participants in the mindfulness condition consumed fewer calories than those in the control conditions, $b = -20.88$, $p = .04$, $\Delta R^2 = .04$, whereas the control conditions did not differ on this outcome, $b = 3.05$, $p = .86$.

Having demonstrated that the mindfulness participants consumed less junk food and fewer total calories, we examined whether this effect was driven by consumption during the free eating period (when condition-specific instructions were *not* given) or during the food rating task (when condition-specific instructions *were* given). Both the free eating and food rating periods allowed for unrestricted access to the same quantities and types of foods. Mindfulness vs. control condition differences in calorie consumption during the food rating task emerged for sweet foods ($p = .02$, $\Delta R^2 = .06$), salty foods ($p = .01$, $\Delta R^2 = .06$), high saturated fat foods ($p < .01$, $\Delta R^2 = .07$), and total calories ($p = .01$, $\Delta R^2 = .06$), but not during the free eating period for any of these food categories ($ps = .09$-$.40$, $\Delta R^2 = .02$-$.04$) nor total calories ($p = .45$, $\Delta R^2 = .02$). The two control conditions did not differ on consumption of any food category at either eating period, $ps > .16$, nor did the mindfulness and control conditions differ on consumption of healthy food at either eating period, $ps > .56$.

As presented in Table 1b, participants differed by condition regarding whether they consumed more calories during the free eating versus food rating task, on average. That is, the mindfulness and no-instruction control conditions did not differ on calories consumed during the rating task versus the free eating period. However, the distraction control group consumed 48% more calories during the rating task than in the free eating period, which is consistent with the fact that they were instructed to work on the word puzzle during the food rating task but not during the free eating period. In sum, mindfulness vs. control condition differences failed to emerge during the free eating period, when they were not reminded of condition instructions, but emerged during the more structured food rating task, when they *were* reminded of conditions. This might be taken as evidence of the efficacy of the condition manipulations.

9.3. Effects on enjoyment and desire ratings

In the multilevel model predicting enjoyment ratings of tasting raisins over time (across the 5 tasting trials), condition interacted with time: that is, the conditions diverged in enjoyment ratings over time. Overall, a significant condition x quadratic slope interaction, $b = -.05$, $p = .02$, showed that in the mindfulness condition, enjoyment rose sharply after the first tasting trial, but in the two control conditions, enjoyment remained low or began dropping after the first tasting trial (see Fig. 3a). This significant quadratic interaction was supported by significant condition x linear time interactions from the first to second and second to third tasting trials ($b = .23$, $p = .01$, and $b = .14$, $p = .02$, respectively), showing the same pattern of group $\times$ time interactions. Despite condition

[5] Due to procedural omission, the self-reported 'compliance with condition instructions' manipulation check administered in Studies 1–2 was not administered in Study 3. However, the PANAS attentiveness scale provided a similar manipulation check. Otherwise, all Study 1–2 measures were included in Study 3.

Table 1a
Number of calories consumed in each food category by condition (across the free eating plus food rating periods combined).

Condition	Calories consumed				
	High sugar foods mean (*SD*)	High salt foods mean (*SD*)	High saturated fat foods mean (*SD*)	"Healthy" foods mean (*SD*)	Total calories mean (*SD*)
Mindfulness	56.81 (53.06)	75.01 (58.01)	105.27 (81.26)	65.04 (66.17)	196.68 (135.24)
Distraction control	92.98 (70.86)	93.33 (62.32)	144.08 (99.10)	69.44 (71.55)	251.20 (142.28)
No-instruction control	93.15 (75.45)	104.25 (70.69)	152.34 (99.59)	62.36 (77.09)	259.65 (159.23)

Note: High sugar foods were M&M's® and Reese's Pieces®, high salt foods were Lay's Potato Chips® and Rold Gold Pretzels®, high saturated fat were Lay's Potato Chips®, M&M's®, and Reese's Pieces®, and healthy foods, which were defined as low sugar and low salt, included unsalted almonds and carrot sticks. The high saturated fat category overlaps with the high sugar and high salt categories; thus "total calories" does not equal the sum of the other categories.

Table 1b
Number of calories consumed in each food category by condition, separated by the free eating and food rating periods.

Condition	Calories consumed		
	Mean (*SD*)		Within-group comparison
	Free eating	Food rating task	
Mindfulness	100.93 (85.28)	96.00 (66.22)	$t(31) = .52$
Distraction control	101.58 (72.51)	149.62 (105.94)	$t(32) = -2.45^{*}$
No-instruction control	127.49 (94.09)	132.15 (92.44)	$t(35) = -.29$

$^{*}p < .05$.
Note: The t value for mindfulness reflects $n = 32$ rather than the full $n = 33$ mindfulness participants due to missing data, and thus differs slightly from reported means.

differences in slopes over time, at tasting trials 1 and 2, no between-condition simple effects (main effects) had yet emerged, but by raisin tasting trials 3 and 4, mindfulness participants approached higher enjoyment than those in the distraction and no-instruction conditions, $b = .28$, and $b = .29$, respectively, $ps = .08$. By raisin tasting trial 5, condition differences in enjoyment ratings no longer approached significance. Apart from condition effects, intrinsic motivation predicted higher enjoyment ratings on each tasting trial, $bs = .05–.06$, $ps < .05$, but did not predict the rate of change in enjoyment ratings over time (slopes), $ps > .56$. Greater hunger scores predicted lower enjoyment slopes in tasting trials 3–5 (linear slope $bs = .16$-$.36$, $ps < .05$), and lower enjoyment ratings at trial 5, $b = .64$, $p = .03$, perhaps because hungrier participants did not enjoy (or appreciate) the very small amount of food they were permitted to taste during the raisin tasting trials.

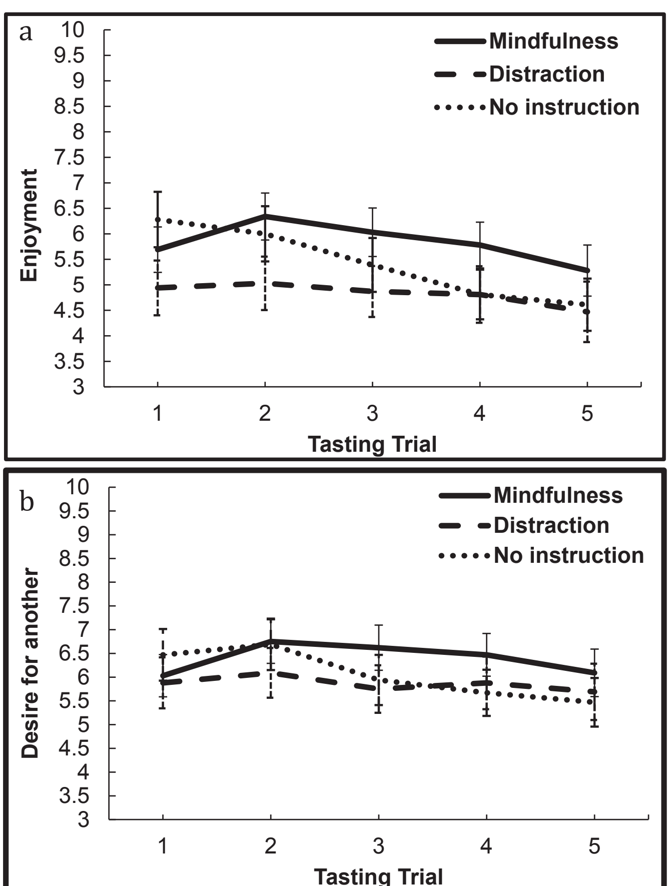

Fig. 3. a. Enjoyment ratings across Study 3 raisin tasting trials by condition (Mean ± 1 SE, mindfulness vs. controls: $p = .02$). b. Desire for another ratings across Study 3 raisin tasting trials by condition (Mean ± 1 SE, mindfulness vs. controls: $p = .04$).

For the desire ratings presented in Fig. 3b, a significant condition x quadratic slope interaction, $b = -.05$, $p = .04$, showed that the mindfulness condition initially increased more steeply in desire ratings than the control conditions and then declined slowly over time, a pattern consistent with the notion that mindfulness led to greater initial desire to eat yet gradual satiety. Convergently, condition x linear slope interactions from raisin tasting trials 1 to 2 and 2 to 3 were found ($b = .25$, $p = .01$, and $b = .15$, $p = .01$, respectively), which again demonstrated a steeper initial rise in desire ratings followed by a slower decline for the mindfulness condition relative to the control conditions. Despite condition differences in slopes over time, that is, in rates of change in desire ratings from one trial to the next, no simple between-group condition differences (main effects) in desire ratings emerged at any single raisin tasting trial, $ps > .18$. Thus, conditions differed in patterns of increase or decrease in desire (and enjoyment) ratings across time, but not in desire ratings at any single time point. Apart from condition effects, intrinsic motivation was again associated with higher raisin tasting ratings throughout, $bs = .07$-$.09$, $ps < .01$, whereas greater hunger predicted lower desire to continue tasting (linear slopes in tasting trials 4 and 5 were significant, $bs = .21$ and $.29$, respectively, $ps < .05$).

9.4. Mediation of calorie consumption by enjoyment

To examine whether the higher enjoyment reported by those in the mindfulness condition helped to explain their lower total calorie consumption during the food rating task, a test of mediation was performed using the Baron and Kenny (1986) method (see Fig. 4). As noted, experimental condition predicted both enjoyment

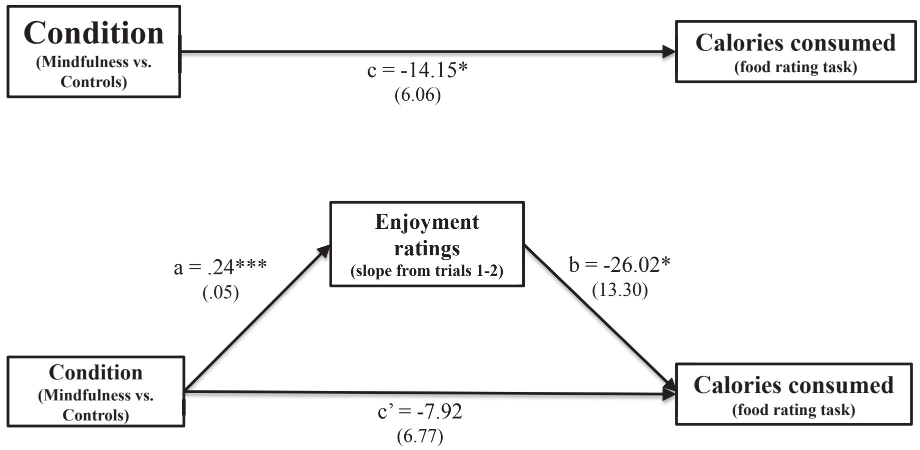

Fig. 4. Mediation of the effect of mindfulness instructions on calories consumed during Study 3 food rating via (earlier) raisin tasting trial enjoyment slopes (unstandardized regression coefficients with standard errors in parentheses). $^{*}p \le .05$, $^{**}p < .01$, $^{***}p < .001$ Note: Condition effect was coded for analysis as 2 = mindfulness, -1 = distraction and no-instruction controls. To simplify, analyses did not include intrinsic motivation or hunger, but findings were similar when they were included.

rating slopes[6] and total calorie consumption during the task (models 1 and 2 of mediation test). Finally, in a model with both experimental condition and enjoyment rating slope,[5] only the latter remained a significant predictor of calorie consumption, $b = -26.02$, $p = .053$, suggesting a mediation effect. Two methods advocated by MacKinnon et al. (2002), the product of coefficients test and the ab/s test, confirmed the statistical significance of this mediation, $P = -10.22$, $p < .01$, and $z' = -1.83$, $p < .01$, respectively. Thus, tasting trial enjoyment ratings mediated the effect of condition on caloric consumption such that more sustained enjoyment during the raisin tasting trials mediated lower caloric consumption in the mindfulness (vs. control conditions) during the subsequent food rating task.

9.5. *Effects on changes in affective state*

We examined changes in positive and negative PANAS scales at 3 time points: baseline, post-raisin tasting trials, and post-food rating task. Multilevel models enabled an examination of change over time using contrast coding to examine condition differences. Conditions did not differ in PANAS ratings over time for positive or negative affect scores, *ps* > .12. Across conditions, negative PANAS ratings decreased over time, $b = -.70$, $p = .002$, $d = .24$, whereas positive PANAS scores showed no changes over time, $b = -.14$, $p = .79$, $d = .02$. The declines in negative affect found here, compared to the increases found in Studies 1 and 2, may be attributable to the open access to a larger variety and quantity of foods for much of the study, in contrast to the limited tasting experiences provided in the first two studies.

9.6. *General discussion*

The present experiments confirmed our predictions that brief mindfulness instructions would enhance the sensory experience of eating while also decreasing caloric consumption, particularly of less healthy foods. Thus, these studies demonstrated that in the context of eating (during a time-limited laboratory session), mindfulness offered both psychological and perhaps physical benefits. Mediation analyses showed a link between greater enjoyment of eating and less subsequent caloric consumption, thereby linking the psychological and physical benefits of mindful eating.

In support of our hypotheses, Study 1 demonstrated that relative to distraction instructions, mindfulness instructions resulted in higher enjoyment and marginally higher desire to continue tasting chocolate, by moderate effect sizes. Condition instructions were delivered verbally in a group format, representing a minimal manipulation. Thus, Study 1 indicated that even brief, simple mindfulness instructions enhanced a sensory tasting experience that was already relatively pleasurable.

In Study 2, our first two hypotheses were largely confirmed using a food with more mixed associations, raisins. Relative to distraction instructions, mindfulness instructions delivered in an individual, experiential format resulted in greater enjoyment and desire to continue tasting by moderate effect sizes, though group differences were not fully significant for enjoyment. Further, unlike in Study 1, our hypothesis concerning condition effects on affective state was generally supported. Negative affect increased from the beginning to the end of Study 2 across both conditions, but increases were significantly lower in the mindfulness condition, by a large effect size. Thus, relative to distraction, mindfulness resulted in lower negative affect in the context of externally regulated eating. These findings replicate in a sensory context a previous finding that brief mindfulness instructions resulted in lower negative affect following emotion-provoking picture viewing (relative to a worry control group; Arch & Craske, 2006). Condition differences in negative affect were not replicated in Study 3 (though the pattern of differences was in the same direction), perhaps because the greater variety, quantity, and choice of foods offered to all participants eliminated condition differences in affect. In Study 3, however, state attentiveness showed greater increases for the mindfulness condition relative to the control conditions, as predicted. Thus generally, mindfulness instructions promoted changes in affect consistent with mindfulness theory (e.g., Brown & Ryan, 2003) that appear to have been sensitive to the particular contexts of each study.[7]

[6] Enjoyment rating slopes began diverging between the mindfulness and control conditions during raisin tasting trial 1. Thus, to capture the beginning of this condition divergence in tasting enjoyment, the linear enjoyment slope between trials 1 and 2 (extracted from HLM 6.08 for each participant) was used as the mediator.

[7] In addition, the overall decreases in positive affect and increases in negative affect from pre-to post-tasting trials in 2, relative to the decreases in negative affect in Study 1, suggest that participants found Study 2 to be challenging or somewhat aversive. Of course, many experiments may be perceived as strange or anxiety-provoking. However, Study 2, conducted in an individual setting, may have been experienced as isolating and thus more negative than in Study 1, which was conducted in a group setting.

Study 3 extended these results by demonstrating three additional findings. First, in further support of our first hypothesis, brief mindfulness instructions enhanced raisin eating enjoyment over and above both no instruction and distraction control conditions. Relative to the two control conditions, mindfulness also led to greater initial increase in desire for more raisins followed by gradual decreases over time. These findings support the notion that group differences in Studies 1 and 2 were likely due to the added benefits of mindfulness over and above typical eating, rather than to the deleterious effects of distraction. Second, mindfulness led to reduced caloric consumption relative to both no instruction and distraction control conditions (these latter two performed similarly), thus supporting hypothesis 4. The benefits of mindfulness took the form of fewer overall calories consumed, driven by reduced consumption of "junk food" (high sugar, salt, and saturated fat snack foods). Third, eating enjoyment rating trajectories early in the study mediated subsequent condition differences in caloric consumption, supporting hypothesis 5. By linking greater eating enjoyment to lower subsequent consumption, Study 3 is the first known to us to examine *why* induced mindfulness may lead to healthier eating outcomes. This finding is consistent with the idea that mindful eating makes "junk" foods less appealing (Kristeller & Wolever, 2010) as well as with research showing that *trait* mindfulness relates to healthier food choices (choosing fruit over sweets), a relation mediated by self-reported preferences for healthy over unhealthy foods (Jordan et al., 2014).

Study 3 did not replicate a previous finding that distracted eating leads to greater caloric consumption than non-distracted eating (e.g., similar to the current no-instruction control condition) (Robinson et al., 2013). However, it is plausible that the distraction and no-instruction control conditions did not differ because we offered a variety of appealing foods, a factor that has been shown to promote greater consumption under typical eating contexts, including those paralleling the present no-instruction control condition (Wansink, 2004).

The present, replicated finding that mindfulness instructions enhanced the enjoyment of eating has two notable implications for mindfulness theory and practice. First, the findings provide the first empirical evidence that brief mindfulness instructions enhance positive sensory experience, augmenting the small body of work on the relation between states of mindfulness and positive outcomes (Arch & Landy, 2015). This evidence is consistent with mindfulness theory stating that the cultivation of mindfulness has positive effects on sensory perception and emotional states (Brown & Ryan, 2003; Kristeller & Wolever, 2010), and deserves further investigation. Second, this work points to a potential pathway of action in mindfulness-based interventions for eating, which have been applied to the treatment of binge-eating disorder (Kristeller & Wolever, 2010) and other eating disorders (Wanden-Berghe et al., 2010). Our findings suggest that mindfulness functions by increasing sensory enjoyment of the eating experience while simultaneously decreasing caloric consumption of unhealthy food, and perhaps reducing the negative affect associated with solitary eating experiences. Dieting, changing poor eating habits, or otherwise maintaining a healthy weight in the context of mindful eating may offer sensory, emotional, and caloric benefits.

9.7. Limitations and future research

The present research is limited by its focus on a healthy undergraduate population, and thus the present conclusions cannot be generalized to community adults or eating disorder patients. It remains unknown, for example, whether a sample of overweight or obese adults (who represent the majority of U.S. adults) would respond to brief mindfulness instructions with a similar capacity to enjoy food without increasing caloric intake. However, given the success of mindfulness and related acceptance-based approaches at helping overweight and obese adults to lose weight (Forman et al., 2013) and reduce binging and emotional eating (Katterman, Kleinman, Hood, Nackers, & Corsica, 2014), this question is worth investigating. Second, two statistical tests of the effects of mindfulness versus distraction on tasting ratings showed marginal statistical significance; both demonstrated condition differences of medium effect size, suggesting that the studies may have been underpowered. Third, the single-item hunger rating did not differentiate between physical hunger and a desire for food, e.g., hedonic hunger (Lowe & Butryn, 2007). Fourth, the diversity of the participants across studies, in which, for example, the largest racial group in Study 2 was East Asian whereas the largest racial group in Study 3 was African-American, represents a study strength as well as a potential limitation. On one hand, the diversity of the samples strengthens our replication effort, providing evidence for these effects among ethnically and racially diverse (albeit young, healthy) adults. On the other hand, future studies should be powered *a priori* to examine potential moderator effects of race and ethnicity on mindfulness and eating outcomes. A final limitation is that these studies took place within time-limited laboratory sessions, which do not mirror everyday eating contexts. Thus, research is needed to evaluate these effects in naturalistic eating contexts over a sustained period of time.

Overall, these findings have potential implications for other common sensory experiences – exercise, bathing, sexual activity, and mundane chores such as washing dishes – representing areas for future investigation. Further research in this area may support the notion that mindfulness can foster "therapeutic lifestyle change" (Walsh, 2011) to enhance health and well-being.

10. Conclusion

The present studies offer initial experimental findings showing that briefly instructed mindfulness can positively impact psychological and behavioral outcomes associated with sensory experience. In particular, showing that brief mindfulness instructions enhanced the enjoyment of eating while also reducing caloric intake provides nascent support for mindfulness as a pathway to greater enjoyment of daily sensory experience and the enhancement of healthy eating behavior.

Conflict of interest

None.

Funding source

This project was supported in part by University of Colorado Boulder startup funds to first author J. J. A.

Acknowledgments

The authors would like to thank Kimberley Brown and Alaina Carr for their research assistance. Please note that author R.J.G. is now at Northern Arizona University, M.D.P. is now at Delivering Happiness, Inc, S.T. is now in private practice, and L.G.K. is now at Kent State University.

References

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Newbury Park, CA: Sage.
Arch, J. J., Brown, K. W., Derek, D. J., Landy, L. N., Brown, K., & Laudenslager, M. L.

(2014). Self compassion training modulates alpha-amylase, heart rate variability, and subjective responses to social evaluative threat in women. *Psychoneuroendocrinology, 42*, 49–58.

Arch, J. J., & Craske, M. G. (2006). Mechanisms of mindfulness: emotion regulation following a focused breathing induction. *Behaviour Research and Therapy, 44*, 1849–1858.

Arch, J. J., & Landy, L. N. (2015). Mindfulness and emotional benefits. In K. W. Brown, J. D. Creswell, & R. M. Ryan (Eds.), *Handbook of mindfulness: Theory and research*. Guilford Press.

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*, 1173–1182.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84*(4), 822–848.

Brown, K. W., Ryan, R. M., & Creswell, J. D. (2007). Mindfulness: theoretical foundations and evidence for its salutary effects. *Psychological Inquiry, 18*(4), 211–237.

Bryant, F. B. (1989). A four-factor model of perceived control: avoiding, coping, obtaining, and savoring. *Journal of Personality, 57*(4), 773–797.

Bryant, F. (2003). Savoring Beliefs Inventory (SBI): a scale for measuring beliefs about savouring. *Journal of Mental Health, 12*(2), 175–196.

Bryk, A. S., & Raudenbush, S. W. (1992). *Hierarchical linear models: Applications and data analysis methods*. Newbury Park, NJ: Sage.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, N.J.: Erlbaum.

Deci, E. L., Eghrari, H., Patrick, B. C., & Leone, D. R. (1994). Facilitating internalization: the self-determination theory perspective. *Journal of Personality, 62*(1), 119–142.

Erisman, S. M., & Roemer, L. (2010). A preliminary investigation of the effects of experimentally induced mindfulness on emotional responding to film clips. [Peer Reviewed]. *Emotion, 10*(1), 72–82. http://dx.doi.org/10.1037/a0017162.

Feingold, A. (2009). Effect sizes for growth-modeling analysis for controlled clinical trials in the same metric as for classical analysis. *Psychological Methods, 14*(1), 43–53.

Forman, E. M., Butryn, M. L., Juarascio, A. S., Bradley, L. E., Lowe, M. R., Herbert, J. D., et al. (2013). The mind your health project: a randomized controlled trial of an innovative behavioral treatment for obesity. *Obesity, 21*(6), 1119–1126.

Frewen, P. A., Evans, E. M., Maraj, N., Dozois, D. J., & Partridge, K. (2008). Letting go: mindfulness and negative automatic thinking. *Cognitive Therapy and Research, 32*(6), 758–774.

Garland, E. L., Gaylord, S. A., & Fredrickson, B. L. (2011). Positive reappraisal mediates the stress-reductive effects of mindfulness: an upward spiral process. *Mindfulness, 2*, 59–67.

Hofmann, S. G., Sawyer, A. T., Witt, A. A., & Oh, D. (2010). The effect of mindfulness-based therapy on anxiety and depression: a meta-analytic review. *Journal of Consulting and Clinical Psychology, 78*(2), 169–183. http://dx.doi.org/10.1037/a0018555.

Institute, S. (1992). *SAS/STAT software: Changes and enhancements. Cary, NC*. SAS technical report P-229.

Institute, S. (1997). *SAS/STAT software: Changes and enhancements through release 6.12. Cary, NC*.

Jordan, C. H., Wang, W., Donatoni, L., & Meier, B. P. (2014). Mindful eating: trait and state mindfulness predict healthier eating behavior. *Personality and Individual Differences, 68*, 107–111.

Kabat-Zinn, J. (1990). *Full catastrophe living: Using the wisdom of your body and mind to face stress, pain, and illness*. New York, NY: Delta.

Katterman, S. N., Kleinman, B. M., Hood, M. M., Nackers, L. M., & Corsica, J. A. (2014). Mindfulness meditation as an intervention for binge eating, emotional eating, and weight loss: a systematic review. *Eating Behaviors, 15*(2), 197–204.

Kiken, L. G., & Shook, N. J. (2011). Looking up: mindfulness increases positive judgments and reduces negativity bias. *Social Psychological and Personality Science, 2*(4), 425–431.

Killingsworth, M. A., & Gilbert, D. T. (2010). A wandering mind is an unhappy mind. *Science, 330*, 932.

Kristeller, J. L., & Wolever, R. Q. (2010). Mindfulness-based eating awareness training for treating binge eating disorder: the conceptual foundation. *Eating Disorders: The Journal of Treatment & Prevention. Special Issue: Eating disorders and mindfulness, 19*(1), 49–61. http://dx.doi.org/10.1080/10640266.2011.533605.

de Leeuw, J., & Kreft, I. (2011). *Software for multilevel analysis. California, USA: department of statistics*. University of California Los Angeles.

Lowe, M. R., & Butryn, M. L. (2007). Hedonic hunger: a new dimension of appetite? *Physiology & Behavior, 91*(4), 432–439.

MacKinnon, D. P., Lockwood, C. M., Hoffman, J. M., West, S. G., & Sheets, V. (2002). A comparison of methods to test mediation and other intervening variable effects. *Psychological Methods, 7*(1), 83–104.

Mooneyham, B. W., & Schooler, J. W. (2013). The costs and benefits of mind-wandering: a review. *Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale, 67*(1), 11–18.

O'Reilly, G. A., Cook, L., Spruijt-Metz, D., & Black, D. S. (2014). Mindfulness-based interventions for obesity-related eating behaviours: a literature review. *Obesity Reviews, 15*(6), 453–461.

Quoidbach, J., Berry, E. V., Hansenne, M., & Mikolajczak, M. (2010). Positive emotion regulation and well-being: comparing the impact of eight savoring and dampening strategies. *Personality and Individual Differences, 49*(5), 368–373.

Raudenbush, S. W., Bryk, A. S., & Congdon, R. (2004). *HLM 6 for windows [Computer software]*. Lincolnwood, IL: Scientific Software International, Inc.

Robinson, E., Aveyard, P., Daley, A., Jolly, K., Lewis, A., Lycett, D., et al. (2013). Eating attentively: a systematic review and meta-analysis of the effect of food intake memory and awareness on eating. *The American journal of clinical nutrition*, 728–742.

Rozin, P., Kabnick, K., Pete, E., Fischler, C., & Shields, C. (2003). The ecology of eating smaller portion sizes in Frane than in the United States help explain the French Paradox. *Psychological Science, 14*(5), 450–454.

Timmerman, G. M., & Brown, A. (2012). The effect of a mindful restaurant eating intervention on weight management in women. *Journal of nutrition education and behavior, 44*(1), 22–28.

Walsh, R. (2011). Lifestyle and mental health. *American Psychologist, 66*(7), 579–592.

Wanden-Berghe, R. G., Sanz-Valero, J., & Wanden-Berghe, C. (2010). The application of mindfulness to eating disorders treatment: a systematic review. *Eating Disorders, 19*(1), 34–48.

Wansink, B. (2004). Environmental factors that increase the food intake and consumption volume of unknowing consumers. *Annual Review of Nutrition, 24*, 455–479.

Watson, D., & Clark, L. A. (1994). *The PANAS-X: manual for the positive and negative affect schedule - expanded form*. The University of Iowa's Institutional Repository: Department of Psychological and Brain Sciences Publications, Iowa Research Online.

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