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The effect of a mindfulness-based body scan exercise on food intake during TV watching

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ABSTRACT

In some studies mindfulness is associated with reduced food consumption, but the underlying mechanisms are less well researched. One potential mechanism is that mindfulness increases attention toward feelings of fullness. Additionally, experimental research on mindfulness and food intake has primarily been conducted in constrained laboratory settings, where it may be easier for participants to notice their internal bodily signals, as opposed to the real world where individuals are often engaged in other activities while eating. The effect of mindfulness on food intake while participants are distracted remains unexplored. This study therefore aimed to examine whether a mindfulness-based body scan exercise reduced food consumption within a distracted environment by increasing attention toward feelings of fullness. Participants (n = 137) listened to a 10-minute body scan meditation, or a 10-minute visualisation (control) meditation. They were then given a bowl of crisps to consume while watching a 10-minute TV show segment. Participants also completed measures assessing proposed mediators, including state mindfulness, attention to bodily sensations and eating automaticity. The body scan manipulation increased state mindfulness but had no direct effect on the other mediators or on food intake (intervention M = 34.79g, SD = 24.06; control M = 33.16g, SD = 23.88). State mindfulness was positively correlated with attention to bodily sensations while eating. Lower eating automaticity and greater reliance on decreased food appeal and physical satisfaction to stop eating were found to be associated with lower food intake. Contrary to previous studies, we found no evidence that a mindfulness body scan reduces food consumption when participants are distracted. Future research should examine the specific conditions under and mechanisms by which mindfulness may influence food consumption.

1. Introduction

There is evidence from experimental studies that practicing mindfulness may be associated with short-term reductions in food intake. However, findings are inconsistent across different mindfulness-based interventions (Tapper, 2017, 2022). Findings are also inconsistent across different populations. For example, Warren, Smith, and Ashwell (2017) concluded that mindfulness was more effective at reducing food intake in populations with overweight and obesity, compared to healthy-weight populations. Additionally, there is considerable variation in the mindfulness practices used across different studies (Tapper, 2022). For example, mindfulness manipulations may focus on inducing present moment awareness of the sensory properties of food (Seguias & Tapper, 2022) or of internal bodily sensations (Fisher, Lattimore, & Malinowski, 2016). Alternatively, studies have also manipulated mindfulness by encouraging acceptance or decentering from feelings of hunger, cravings, or food-related thoughts (Jenkins & Tapper, 2014).

Given the variety of ways in which mindful eating can be operationalised, there are several possible mechanisms of action underlying the effects of mindfulness on food consumption. One proposed mechanism centers around the idea that mindfulness enhances interoceptive awareness of hunger and satiety (Tapper, 2022; Warren et al., 2017). Interoceptive awareness is defined as the process of perception and interpretation of internal bodily signals (Khalsa & Lapidus, 2016). This means that mindfulness may allow individuals to better perceive and interpret their physiological signals of hunger and fullness, which may in turn cause them to reduce their food intake by only eating when they are hungry and stopping eating when they are full. One widely used mindfulness exercise is the body scan meditation (Fischer, Messner, & Pollatos, 2017), which instructs participants to focus on their breath and

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physical sensations while sequentially attending to different body parts. The exercise typically prompts listeners to notice when they become distracted and to redirect their attention back to the body, encouraging meta-awareness and attention regulation, which may enhance attention toward bodily sensations and therefore heighten interoceptive awareness of hunger and satiety.

Although much of the research exploring mindfulness and interoceptive awareness has measured interoception using a heartbeat perception task or self-report measures (Gibson, 2019), there is some evidence for the effect of mindfulness on interoceptive awareness of hunger and satiety cues. For example, Van De Veer, Van Herpen, and Van Trijp (2016) found that a body scan exercise improved awareness of satiety signals as assessed using a self-reported questionnaire. Palascha, van Kleef, de Vet, and van Trijp (2021) found that participants who had performed a body scan exercise detected the onset of hunger approximately 18 min earlier than those in a control group following a standardised lunch preload. Moreover, higher self-reported mindfulness has also been associated with greater awareness of self-reported physiological signals of hunger and satiety (Beshara, Hutchinson, & Wilson, 2013). Nevertheless, empirical studies investigating increased interoceptive awareness of hunger and satiety signals as an underlying mechanism for the impact of mindfulness on consumption are scarce and yield inconclusive findings (Vanzhula & Levinson, 2020).

Some evidence for this mechanism of action comes from studies indicating that engaging in a body scan meditation is associated with a reduction in food intake. For example, Jordan, Wang, Donatoni, and Meier (2014) found that participants who performed a body scan exercise consumed 24% fewer calories than a control group in a subsequent taste testing task. Fisher et al. (2016) similarly observed a reduction in food intake following a mindful attention induction in which participants were encouraged to notice physical sensations similar to a body scan. Questionnaire measures of awareness of physiological signals of hunger and satiety were also found to be associated with smaller self-reported portions of energy dense foods consumed over a 1-week period (Beshara et al., 2013).

However, several studies have failed to find an effect of interoceptive awareness on food consumption. For example, Martin et al. (2017) did not find a reduction in calorie intake following a 6-week intervention where participants were instructed to attend to internal signals of hunger and satiety during their meals. Likewise, Hsu and Forestell (2021) reported no significant difference in food intake between participants who listened to a body scan meditation and a control group. Some studies have only observed effects under certain conditions. For example, Marchiori and Papies (2014) found that a body scan only had an effect on unhealthy food intake when participants were hungry. Van De Veer et al. (2016) observed that compared to two control groups, a body scan exercise resulted in increased consumption following a small preload. However, there were no differences in consumption across the three conditions after a large preload. These inconsistencies suggest there may be variations in the strength of hunger and satiety cues, with hunger signals being more noticeable compared to satiety cues.

This idea is supported by Palascha et al. (2021) who identified discrepancies in the effect of mindfulness on perception of hunger and satiety signals. Awareness of hunger was investigated by asking participants to report the time of their first hunger signal following a standardised lunch preload and awareness of satiety was explored using a water-load task that measured satiation threshold. Participants who performed a body scan were able to perceive their first hunger signals sooner compared to a control group. However, the body scan intervention did not have a significant impact on awareness of satiety.

One reason for this finding may be that awareness of satiety signals was measured in a constrained laboratory setting with no distractions, and therefore ceiling effects were reached in terms of participants' attention to their satiety cues. In contrast, hunger signals were explored outside the laboratory in a real-world setting. It could be argued that in everyday life, people tend to eat while busy with other tasks and their attention may be elsewhere whereas in the laboratory there is naturally more focus on their eating and their body and thus the body scan may not increase awareness any further. This could explain why the mindfulness intervention appeared to be effective at increasing attention to hunger, but ineffective at improving awareness of satiation. Thus, it can be speculated that a mindfulness intervention may be more effective in increasing awareness of satiety cues outside of a quiet laboratory environment, when participants' attention is divided. This notion is supported by the literature exploring food consumption under distracted conditions. A systematic review and meta-analysis by Robinson et al. (2013) found that distraction increases both immediate and subsequent food consumption. Therefore, it is possible that a mindfulness exercise could be more effective at reducing food intake when a person is in a distracted environment, by prompting them to repeatedly return their attention to their bodily sensations of hunger and satiety. However, to date, there are no studies exploring this possibility.

In light of the above, the present study had two key aims. First, to examine whether a mindfulness body scan is effective at reducing food intake when participants are distracted. Second, to further explore a possible underlying mechanism of action; that mindfulness increases awareness of satiety signals, which in turn reduces food intake. Food consumption was compared following a body scan meditation or a visualisation exercise (control). Food consumption was measured while participants were watching a segment from a TV show to distract them, thus better replicating an everyday scenario in which individuals often consume food.

We predicted that participants in the mindfulness body scan condition would subsequently consume less snack food compared to the control group. Additionally, if the body scan condition increased awareness of satiety signals, we expected participants in the body scan condition to have higher state mindfulness and report greater attention to their stomach and mouth while watching the video clip. We also expected them to report lower eating automaticity and to stop eating for reasons relating to decreased food appeal and physical satisfaction (appeal-satisfaction). The study also collected data on these additional measures, and it was predicted that these four variables would mediate the effect of condition on food consumption (see Fig. 1). Specifically, we expected that the body scan would increase state mindfulness, which would in turn increase attention to the stomach and mouth, decrease eating automaticity, and increase the likelihood of stopping eating due to decreased food appeal and physical satisfaction. This would in turn lead to reduced food consumption.

2. Method

2.1. Sample size

Based on a similar study by Jordan et al. (2014), a medium effect size of mindfulness body scan on food intake was used to inform power analysis. Assuming 80% power and 5% alpha for an independent samples *t*-test, a sample size of 128 participants was calculated using G*Power. An additional 10% (13 participants) were recruited to account for any exclusions.

2.2. Participants

A total of 141 participants took part in the study. Participants were aged between 18 and 59 years and the mean age was 21.3 ($SD = 7.4$). The sample consisted of 85.8% female participants ($n = 121$) and over half (52.5%) were current university students ($n = 74$). Participants' ethnic backgrounds were White (26.2%), Mixed (7.8%) Asian (47.5%), Black (5%) and other (13.5%). Participants were recruited via online platforms and poster advertisements around City, University of London. They received either course credits or a £5 shopping voucher for their participation. The study received ethical approval from the City, University of London Psychology Department Research Ethics Committee

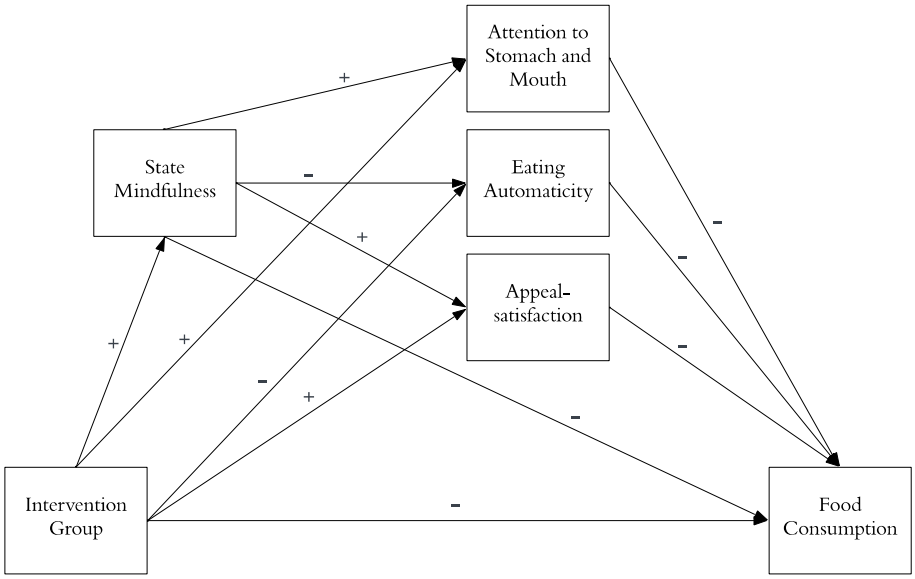

Fig. 1. Hypothesised model displaying the expected relationships between the intervention, food consumption and mediator variables.

(ETH2122-0935). The method and analysis strategy were pre-registered with the Open Science Framework (https://osf.io/c5qug/).

2.3. Materials

2.3.1. Audio recordings

Scripts were developed for the intervention and control audio recordings, and they were recorded at City, University of London. There were two audio recordings per condition: a 3-minute practice audio and the main 10-minute audio. The practice audios began and ended in the same way as the main audios but were shortened. The intervention audios consisted of an adapted version of a body scan meditation developed by Kabat-Zinn (2002). The audios instructed participants to pay attention to specific parts of their body starting from the head down to the toes, and included prompts to remind participants to bring back their attention to their body if their mind began to wander. The control audios consisted of a visualisation exercise which was adapted from a guided imagery meditation by May, Andrade, Batey, Berry and Kavanagh (2010). The exercise required participants to imagine themselves walking through a forest. See Appendix 1 (in supplementary materials) for the full scripts.

2.3.2. Snack food

Following Ogden et al. (2013), participants were provided with 100g (526 kcal) of Walkers ready salted crisps as a snack while they watched the TV show. Only one type of food was offered to limit measurement to food intake, as opposed to food choice.

2.3.3. TV show

A 10-minute clip from the American sitcom 'Friends' was selected based on use in previous studies (Ogden et al., 2013). An episode was chosen in which there was no mention of food and no scenes in which the characters were eating.

2.4. Measures

2.4.1. Demographics

Participants indicated their age, sex, ethnicity, and education level.

2.4.2. Hunger

Participants indicated their hunger level on a 100 cm Visual Analogue Scale (VAS). This measure was disguised as a general mood assessment amongst nine other emotions and feelings, such as 'jittery' and 'excited'. Note, it was not possible to control for baseline fullness as this would have required telling participants to avoid eating prior to the study which would have resulted in aim guessing. Previous studies have used a measurement of the last time at which participants ate, however, it has been shown that this is not a good indication of hunger or fullness levels (Rogers & Hardman, 2015). Additionally, controlling for baseline fullness was not imperative as we offered a snack as opposed to a meal, and research has shown that individuals do not only snack when they are hungry (Cleobury & Tapper, 2014).

2.4.3. State mindfulness

State mindfulness was measured using three items from the State Mindfulness Scale (Tanay & Bernstein, 2013). These were 'I felt aware of what was happening inside of me', 'I clearly physically felt what was going on in my body' and 'I felt in contact with my body'. Participants rated how well each statement described their experiences while they were listening to the audio on a scale of 1 (not at all) to 5 (very well). The state mindfulness measure served as a manipulation check to determine whether the body scan exercise resulted in higher levels of state mindfulness than the control exercise.

2.4.4. Manipulation check

Three statements relating to the visualisation exercise were used in the manipulation check. These were 'I saw a clear image of trees in my mind's eye', 'I felt transported outside of the room' and 'I could see vivid colours in my mind's eye'. Participants rated how well each statement described their experiences while listening to the audio on a scale of 1 (not at all) to 5 (very well).

2.4.5. Suspicion probe

Participants indicated whether they had any ideas about the study's hypotheses, whether they had previously learned anything about the study and whether their behaviour was influenced by any of the tasks they did in the study. Their responses were used to ascertain whether they guessed the study aims.

2.4.6. Attention to the stomach and mouth

Six items were used to assess participants' attention to their stomach and mouth areas while they were watching the show. These items asked participants to indicate to what extent they were paying attention to the sensations in their stomach, their body's hunger and fullness signals, the

sensations inside their mouth, the taste of the food in their mouth, the texture of the food in their mouth, and how full they felt. Each item was rated on a 5-point Likert scale ranging from 1 (not at all) to 5 (very well).

2.4.7. Eating automaticity

The extent to which participants ate automatically while watching the show was assessed using the 4 automaticity items from the Self-report Habit Index (Verplanken & Orbell, 2003). Each item was rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

2.4.8. Reasons individuals stop eating

The 'Decreased food appeal' (3 items) and 'Physical satisfaction' (3 items) subscales from the 15-item Reasons Individuals Stop Eating Questionnaire (RISE-Q; Chawner, Yu, Cunningham & Rolls, 2022) were used to assess the extent to which participants stopped eating the crisps due to decreased food appeal and physical satisfaction while watching the show. Each item was rated on a 7-point Likert scale ranging from 1 (completely untrue for me) to 7 (completely true for me). This variable will henceforth be referred to as appeal-satisfaction.

2.4.9. Trait interoceptive awareness

Trait interoceptive awareness was measured using the Sensitivity to Physiological Signals of Hunger and Satiation subscales of the Multidimensional Internally Regulated Eating Scale (MIRES; Palascha, van Kleef, de Vet, & van Trijp, 2020). There were 6 items, and each item was rated on a 7-point scale ranging from 1 (completely untrue for me) to 7 (completely true for me).

2.4.10. Trait mindful eating

Trait mindful eating was assessed using 3 domains ('Eating while paying attention to hunger and satiety cues', 'Being aware of eating' and 'Eating while not being distracted') from the Mindful Eating Behaviour Scale (Winkens et al., 2018). Each item was rated on a 5-point Likert scale ranging from 1 (never) to 5 (very often).

2.4.11. Restrained eating

Restrained eating was assessed using the cognitive restraint scale (6 items) from the 21-item Three Factor Eating Questionnaire (TFEQ; Cappelleri et al., 2009). Five items were rated on a scale of 1 (definitely true/almost never/unlikely) to 4 (definitely false/almost always/very likely) and one item was rated on a scale of 1–8.

2.4.12. Dieting and healthy eating

Participants indicated whether they were currently dieting to lose weight, and how important healthy eating is to them on a scale of 1 (not at all important) to 5 (extremely important).

2.4.13. Crisps liking and consumption

Participants indicated how much they like the taste of ready salted crisps on a scale of 1 (dislike a lot) to 5 (like a lot). In addition, participants were asked to indicate whether they had eaten any crisps, and to give a reason if they did not.

2.4.14. Height and weight

Height and weight were measured via self-report.

2.4.15. Crisp consumption

The amount of crisps consumed by participants was calculated by weighing the crisps before and after consumption (grams).

2.5. Procedure

To ensure participants were not aware that their food intake was being measured, they were told that the study was investigating the effect of relaxation on cognitive performance. The study was carried out during the day from 10am to 5pm apart from during lunch hours (between 12pm and 2pm), to avoid participants being too hungry and treating the snack provided as their lunch.

The study was delivered on Qualtrics. Upon signing the consent form, participants entered their demographics and were randomised to either the intervention or control condition. Due to sex differences in food intake, randomisation was stratified by sex to ensure there were equal numbers of males and females in the two conditions. Participants completed a measure of hunger and a bogus cognitive performance task to keep in line with the cover story. This consisted of 4 questions where participants were presented with 4 colour names (blue, yellow, green, red) written in different print colours and they had to identify the option where the colour name corresponded to the print colour. This took approximately 1 minute.

Participants then listened to the mindfulness or control audio, which they were told was a relaxation exercise. In both conditions, participants were first introduced to the short 3-minute practice audio before the main 10-minute audio, following a similar repeated practice methodology used by Wilson, Senior, and Tapper (2021). This allowed participants a chance to practice the exercise. At the end of the audio, participants in both conditions were told to continue using the relaxation technique throughout the rest of the study. This was in line with the cover story and aimed to encourage participants in the mindfulness condition to continue to pay attention to their body during food consumption. Following this they completed the state mindfulness questionnaire and manipulation check. Participants then repeated the cognitive performance task to keep in line with the cover story.

Participants then moved to a sofa where they watched 10 minutes of a TV show on a monitor that was placed on the coffee table in front of them. They were told this was another relaxation exercise. A tray with a bowl of crisps (100g) and a glass of water was placed next to them on the sofa and they were told to relax, make themselves comfortable and help themselves to the crisps. Participants then returned to the computer to complete the suspicion probe and some more questionnaires on Qualtrics. They were then debriefed about the real aims of the study and consent was obtained to measure their food intake. Once participants left the room, the leftover crisps were weighed.

2.6. Data analysis

Data were analysed in the IBM SPSS statistical analysis package (version 28). An independent *t*-test was used to assess the effect of intervention group on the visualisation measure (manipulation check). To test the effect of intervention group on food consumption, and the mediating effects of state mindfulness, attention to the stomach and mouth, eating automaticity and appeal-satisfaction, a combined parallel and serial mediation model via the PROCESS macro in SPSS was used (Hayes, 2017). Indirect effects were subjected to follow-up bootstrap analyses with 5000 bootstrap samples and 95% bias corrected confidence intervals. Indirect effect estimates were considered significant when the confidence intervals did not contain zero.

In the pre-registered protocol for this study, we planned to run one model with intervention group as the predictor variable, food consumption as the outcome variable, and state mindfulness, attention to the stomach and mouth, eating automaticity and appeal-satisfaction as mediator variables with hunger as a covariate. However, 11 participants did not consume any food and therefore had missing appeal-satisfaction scores. As the PROCESS macro excludes cases listwise, running the planned model would have resulted in a loss of data. Therefore, in a deviation from the protocol, two separate models were run. First, the model was run without appeal-satisfaction as a mediator in order to capture data from all participants. The main findings are reported from this model. The model was then run again with the addition of appeal-satisfaction as a mediator to capture the findings relating to this variable.

3. Results

3.1. Participant characteristics

Two participants were excluded because they correctly guessed the aims of the study and a further two participants were excluded because they stated that they did not consume any food due to reasons unrelated to hunger and dieting status (1 did not like crisps and 1 had retainers in), therefore the final sample consisted of 137 participants. Results from sensitivity analyses with the inclusion of data from the excluded participants are reported in section 3.6. Due to an additional 9 participants not consuming any food, the analyses with the appeal-satisfaction mediator consisted of 128 participants. Table 1 shows participant characteristics across the experimental and control groups. Participants were well matched across all characteristics with the exception of dieting status, as substantially more participants in the control group reported that they were dieting to lose weight. Results from sensitivity analysis with dieters excluded are reported in section 3.8.

3.2. Manipulation check

The manipulation check consisted of three visualisation items and three state mindfulness items. Visualisation scores were calculated using the average of the ratings on the three visualisation items, and state mindfulness scores were calculated by summing ratings of the three state mindfulness items. Higher scores indicate greater visualisation and state mindfulness following the manipulation respectively. Participants in the control group ($M = 3.75$, $SD = 1.02$) had significantly higher visualisation scores than those in the experimental group ($M = 2.06$, $SD = 0.84$), $t(135) = -10.55$, $p < 0.001$. There was also a significant effect of intervention group on state mindfulness score ($b = 1.11$, $SE = 0.48$, 95% CI [−2.05, −0.17], $\beta = 0.40$, $p < 0.05$). State mindfulness was higher in the mindfulness group ($M = 11.22$, $SD = 2.75$) compared to the control group ($M = 10.11$, $SD = 2.80$) indicating that the body scan was effective in increasing state mindfulness as hypothesised.

Table 1
Characteristics of study participants as a function of condition.

Characteristic	Experimental (n = 67)	Control (n = 70)
Age (*M, SD*)	20.2 (4.5)	21.7 (8.3)
Sex (% of females)	86.6%[a]	87.1%
Education		
A-level	23.9%	32.9%
BTEC	4.5%	1.4%
Currently studying an undergraduate degree	47.8%	50.0%
Undergraduate degree	3.0%	4.3%
Currently studying a postgraduate degree	4.5%	2.9%
Postgraduate degree	1.5%	4.3%
Other	14.9%	4.3%
Ethnicity		
Asian/Asian British	41.8%	52.9%
Black/African/Caribbean/Black British	9.0%	1.4%
White	26.9%	25.7%
Mixed/Multiple ethnic groups	10.4%	4.3%
Other	11.9%	15.7%
BMI (*M, SD*)[b]	23.1 (4.2)	22.1 (4.1)
Baseline hunger on VAS of 0–100 (*M, SD*)	31 (25)	29 (28)
Percentage that consumed the food	95.5%	91.4%
Percentage dieting to lose weight	7.5%[c]	22.9%
Importance of healthy eating score on Likert scale of 1–5 (*M, SD*)	3.2 (0.9)	3.2 (0.9)
Liking of crisps on Likert scale of 1–5 (*M, SD*)	4.0 (1.0)	4.1 (0.9)

[a] n = 65 due to missing data.
[b] n = 48 and 53 respectively due to missing data.
[c] n = 65 due to missing data.

3.3. Effect of the mindfulness intervention on food intake

The mean amount of food consumed (in grams) in the experimental and control conditions are presented in Table 2. The direct effect of intervention group on food consumption was not significant ($b = 0.69$, $SE = 3.83$, 95% CI [−6.88, 8.26], partially standardised $\beta = 0.03$, $p = 0.85$), therefore our hypothesis that the mindfulness intervention would reduce food intake was not supported.

3.4. Mediation analyses

The hypothesised mediation model with standardised coefficients is presented in Fig. 2. Contrary to our hypotheses, intervention group did not significantly affect attention to the stomach and mouth ($b = 0.08$, $SE = 0.13$, 95% CI [−0.18, 0.34], $\beta = 0.10$, $p = 0.54$), eating automaticity ($b = 0.62$, $SE = 0.74$, 95% CI [−0.85, 2.08], $\beta = 0.14$, $p = 0.41$), or appeal-satisfaction ($b = 0.53$, $SE = 1.33$, 95% CI [−2.11, 3.16], $\beta = 0.07$, $p = 0.69$).

As predicted, state mindfulness was significantly positively associated with attention to the stomach and mouth ($b = 0.11$, $SE = 0.02$, 95% CI [0.07, 0.16], $\beta = 0.39$, $p < 0.001$), however, it did not relate to eating automaticity ($b = -0.07$, $SE = 0.13$, 95% CI [−0.33, 0.19], $\beta = -0.05$, $p = 0.59$), appeal-satisfaction ($b = 0.06$, $SE = 0.24$, 95% CI [−0.41, 0.53], $\beta = 0.02$, $p = 0.80$) or food intake ($b = -0.88$, $SE = 0.74$, 95% CI [−2.33, 0.58], $\beta = -0.10$, $p = 0.23$).

Attention to the stomach and mouth did not significantly relate to food consumption ($b = 2.34$, $SE = 2.50$, 95% CI [−2.61, 7.28], $\beta = 0.08$, $p = 0.35$) contrary to hypotheses. However, results did indicate that eating automaticity was positively related to increased food intake ($b = 1.73$, SE = 0.45, 95% CI [0.84, 2.62], $\beta = 0.31$, $p < 0.01$) and appeal-satisfaction decreased food intake ($b = -0.59$, SE = 0.26, 95% CI [−1.11, −0.07], $\beta = -0.20$, $p < 0.05$) as predicted. These results indicate that individuals with higher eating automaticity scores consumed more food, and those with greater reliance on decreased food appeal and physical satisfaction to stop eating consumed less food.

Table 3 presents the three serial mediation pathways that were hypothesised. The analyses revealed that contrary to our hypotheses, the effect of condition on food intake was not serially mediated by state mindfulness and attention to the stomach and mouth, state mindfulness and eating automaticity, or state mindfulness and appeal-satisfaction.

3.5. Hunger

Hunger was entered as a covariate in the model, and it was found that increased hunger was associated with increased food intake ($b = 0.20$, $SE = 0.07$, 95% CI [0.06, 0.34], $\beta = 0.22$, $p < 0.01$).

3.6. Sensitivity analyses

Sensitivity analyses were conducted with data from the two aim guessers included, and the pattern of effects remained unchanged. Analyses were also repeated with data from the two participants who did not consume any food due to reasons other than hunger or dieting included. The pattern of results remained unchanged.

Analyses were repeated excluding data from 11 participants who did not consume any food (i.e. using the same model in which appeal-satisfaction was included as a mediator). The effect of group on state mindfulness ($b = 0.92$, $SE = 0.50$, 95% CI [−0.06, 1.91], $\beta = 0.31$, $p = 0.07$) and the effect of hunger on food intake ($b = 0.13$, $SE = 0.08$, 95%

Table 2
The amount of food consumed in grams as a function of condition.

Condition	Food intake in grams (*M, SD*)
Experimental (n = 67)	34.79 (24.06)
Control (n = 70)	33.16 (23.88)

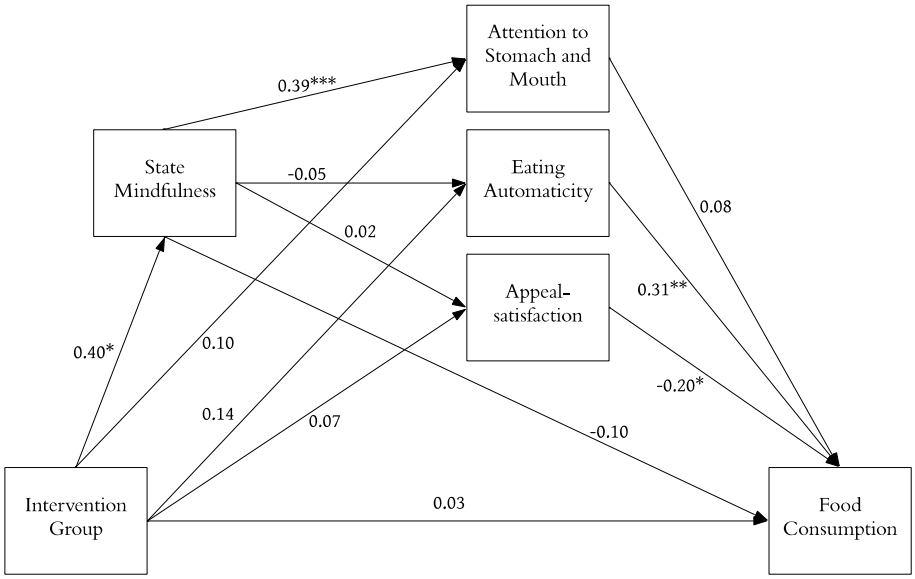

Fig. 2. Standardised coefficients are presented, *p < 0.05, **p < 0.01, ***p < 0.001. Direct effect of intervention group on food consumption is partially standardised.

Table 3
Path coefficients for mediated relationships in hypothesised model.

Path	*b*	*SE*	*β*	95% CI LL	95% CI UL
Intervention group -> State Mindfulness -> Attention to Stomach and Mouth -> Food Consumption	0.29	0.37	0.01	−0.28	1.20
Intervention group -> State Mindfulness -> Eating Automaticity -> Food Consumption	−0.14	0.29	−0.01	−0.80	0.40
Intervention group -> State Mindfulness -> Appeal-satisfaction -> Food Consumption	−0.03	0.17	−0.002	−0.47	0.26

b = indirect path coefficient, *SE* = bootstrapped standard error, *β* = partially standardised coefficient, CI = confidence interval, LL = lower level, UP = upper level.

CI [−0.02, 0.28], $\beta = 0.16$, $p = 0.08$) became non-significant. The pattern of effects for the rest of the analyses remained unchanged.

Further sensitivity analyses were conducted with data from 12 participants excluded due to minor deviations from the protocol. These included those whose participation in the study did not follow the standard procedure (3 observed using their phone during the study, 3 where the crisps had to be placed on the table instead of the sofa, 2 brought and consumed their own drink during the study, 2 completed the study quicker than the standard time, 1 interrupted by a fire alarm, and 1 who went to the kitchen to wash their hands). The pattern of effects remained unchanged.

3.7. Exploratory analyses: effects of other variables on food consumption

The effects of trait mindful eating, interoceptive awareness, age, BMI, sex, and education on food consumption were explored in a multiple regression model. The overall model was not significant, $F(12, 87) = 1.01$, $p = 0.45$, $R^2 = 0.12$, $R^2_{adjusted} = 0.001$. Because hunger may moderate any association between mindful eating or interoceptive awareness and food intake, it was not entered in the initial model. Therefore the model was run again with the addition of hunger as a predictor, but the overall model was still not significant, $F(13, 86) = 1.48$, $p = 0.14$, $R^2 = 0.18$, $R^2_{adjusted} = 0.06$.

3.8. Exploratory sensitivity analysis

Sensitivity analyses were carried out with data from 21 participants who reported that they were dieting excluded. The pattern of effects remained unchanged in the main model. The direct effect of intervention group on food consumption was not significant ($b = 1.08$, $SE = 4.31$, 95% CI [−7.46, 9.61], partially standardised $\beta = 0.05$, $p = 0.80$). The mean amount of food intake was 34.75g ($SD = 23.38$) in the mindfulness group and 34.33g ($SD = 24.42$) in the control group. In the model with appeal-satisfaction, intervention group significantly predicted state mindfulness ($b = 1.28$, $SE = 0.53$, 95% CI [0.22, 2.36], $\beta = 0.45$, $p < 0.05$). For all other analyses the pattern of effects remained unchanged.

Analyses were also repeated with data from 31 participants who reported that they did not like crisps excluded. These were participants who rated their liking of crisps as either 'dislike a lot', 'dislike a little' or 'neither like nor dislike'. The pattern of effects remained unchanged in the main model. The direct effect of intervention group on food consumption was not significant ($b = 4.07$, $SE = 4.31$, 95% CI [−4.48, 12.63], partially standardised $\beta = 0.18$, $p = 0.35$). Mean food intake was 39.76g ($SD = 21.97$) in the mindfulness group and 35.49g ($SD = 23.92$) in the control group. In the model with appeal-satisfaction, intervention group significantly predicted state mindfulness ($b = 1.18$, $SE = 0.55$, 95% CI [0.10, 2.27], $\beta = 0.42$, $p < 0.05$), and hunger significantly predicted food intake (($b = 0.21$, $SE = 0.09$, 95% CI [0.03, 0.39], $\beta = 0.24$, $p < 0.05$). The pattern of effects remained unchanged for all other analyses. Supplementary analyses are presented in Appendix 2 (in supplementary materials).

4. Discussion

Contrary to our hypotheses, the results of this study showed no direct or indirect effects of a mindfulness-based body scan on subsequent food consumption during TV watching. This finding is inconsistent with prior research by Jordan et al. (2014), who reported that a body scan exercise resulted in significantly lower food consumption, and Fisher et al. (2016) who also found a reduction in food intake following a similar mindfulness-based exercise. These previous studies were not carried out under distracted conditions, suggesting that the effects of a body scan

exercise on consumption may only occur in non-distracted environments.

However, the observed absence of an effect of the body scan on food intake is in line with previous studies by Martin et al. (2017), Hsu and Forestell (2021), Marchiori and Papies (2014), and Van De Veer et al. (2016) that failed to find an effect of similar mindfulness exercises on food consumption. Furthermore, this finding aligns with the broader body of research in the mindful eating field that has assessed food intake outside the laboratory such as recent studies by Whitelock et al. (2019), Tapper and Seguias (2020) and Seguias and Tapper (2022). These studies employed a mindful eating exercise in which participants were instructed to pay attention to the sensory properties of their food as they ate and found no effect on the amount of food consumed. The collective evidence suggests a consistent pattern of mindfulness exercises demonstrating limited impact on overall food intake across various studies.

While the body scan practice did not influence food consumption, it was found that participants in the intervention group demonstrated higher levels of state mindfulness, which were associated with greater attention toward the stomach and mouth while watching the video clip and eating the crisps. However, this heightened awareness did not lead to reduced food intake which suggests that increased awareness of satiety signals alone may not be sufficient to curb food consumption, as individuals may choose to continue eating beyond the point of fullness. Alternatively, it may be the case that participants did not actually achieve fullness while eating during the study, although we did not measure satiety. It is also plausible that the effects of the intervention dissipated quickly following the body scan exercise, thus failing to translate into a change in behaviour. These findings indicate that simply encouraging individuals to "be more mindful" may not be enough to reduce their food intake, and future research should explore alternative strategies and mechanisms of action.

Furthermore, there was no evidence that mindfulness influenced eating automaticity or individuals' tendency to stop eating due to decreased food appeal and physical satisfaction. This suggests that although mindfulness may increase awareness of bodily sensations, including feelings of fullness, it may not directly impact the specific psychological processes involved in food consumption. Several key novel findings emerged from the analyses in relation to these processes. Notably, individuals who reported eating automatically while watching the show consumed more food, emphasising the potential importance of conscious awareness in regulating food intake. Moreover, participants who reported stopping eating due to decreased food appeal and physical satisfaction consumed less food, validating the 'Decreased food appeal' and 'Physical satisfaction' subscales of the 15-item RISE-Q (Chawner, Yu, Cunningham, Rolls, & Hetherington, 2022). This supports the notion that attending to food appeal and physical satisfaction may help individuals to stop eating sooner and thus reduce their overall food intake. This is the first study we are aware of to find associations between these variables and an objective measure of food intake. Collectively, these findings highlight the potential importance of present moment awareness in regulating food intake. Future mindfulness interventions targeting eating automaticity may therefore be more promising in influencing food consumption.

The exploratory analysis revealed no indications of a relationship between food intake and trait mindful eating or trait interoceptive awareness. This finding is in contrast to previous research by Jordan et al. (2014) and Farrar, Plagnol, and Tapper (2022) who found that higher trait mindfulness was associated with making healthier food choices, and Beshara et al. (2013) who found trait mindful eating to be associated with consuming smaller portion sizes. However, Beshara et al. (2013) used self-report to measure portion sizes which may be unreliable, and Jordan et al. (2014) and Farrar et al.'s (2022) results related to food choice, as opposed to intake. It is plausible that having higher levels of trait mindfulness or interoceptive awareness does not necessarily translate to consuming less food. Individuals in the present study may have been mindful and aware of their satiety signals but consumed food according to their personal satisfaction levels. This interpretation is supported by the finding that increased hunger was associated with higher food intake, as it suggests that participants consume food in accordance with their hunger levels.

The study has a number of limitations that should be considered. To avoid drawing attention to the aims of the study and demand characteristics, participants were told to continue using the "relaxation technique" throughout the rest of the study but were not explicitly instructed to maintain mindfulness and attention to their body while they were watching the TV show and consuming the food, potentially limiting the effectiveness of the intervention. Therefore, it is possible that although state mindfulness increased immediately following the body scan exercise, participants did not continue to be mindful while they were distracted with the TV show. Providing specific instructions for participants to continue paying attention to their bodies in a distracted setting may yield more pronounced effects on food intake. This could be explored in future research by encouraging participants to engage in a mindfulness practice while they are consuming food in a distracted environment. Future research could also explore the effects of a body scan exercise on food consumption during a longer mealtime period to assess its potential efficacy.

The design of the study poses a further limitation. Although several measures were taken to match the study conditions to a real-world eating scenario, the study was conducted in a controlled laboratory environment. This means the findings may not accurately reflect individuals' eating behaviour in the real world and future research may explore the effects of a body scan on food consumption while distracted in a more ecologically valid scenario. A final limitation of the study relates to the participant characteristics. Over half of the sample consisted of university students and the mean age was 21 years, therefore the findings may be specific to a university-aged sample. It is recommended for future research to use a sample beyond university students. A further recommendation for future research would be to examine the efficacy of the body scan practice with individuals who are trying to manage their weight, given that Warren et al. (2017) found mindfulness interventions to be more effective at reducing food intake in populations with overweight and obesity compared to healthy weight populations. The mean BMI of participants in this study was 22.6 which falls within the healthy range. Therefore, it is plausible that findings may be different in individuals with higher BMIs.

Despite its limitations, the study has strengths. Primarily, the study was pre-registered and used a relatively well powered and larger sample size than previous studies on mindfulness and food intake. In addition, the use of a cover story ensured that participants were blind to the study aims, reducing demand characteristics and social desirability bias. Furthermore, the study employed an active control condition which was carefully matched to the intervention condition to control for the effect of relaxation, as relaxation has been shown to influence food consumption (Masih, Dimmock, Epel, & Guelfi, 2017). A significant portion of existing studies in this field have failed to control for these aspects (Tapper, 2022). Therefore, these differences in methodological best practice may in part explain why we failed to find an effect of a mindfulness-based body scan on food intake, unlike some earlier studies.

In conclusion, a brief body scan exercise increased state mindfulness but did not appear to reduce subsequent food consumption while participants were distracted. However, two key findings emerged from the study showing that reduced food intake was associated with lower eating automaticity and a greater reliance on reasons related to decreased food appeal and physical satisfaction to stop eating. These findings highlight the complex nature of food consumption and the multifaceted factors that contribute to eating behaviour. Considering the contextual specificity of mindfulness, further investigation is needed to determine the conditions under which mindfulness is effective or ineffective in reducing food consumption and to explore other potential underlying mechanisms.

Author contributions

The study was conceived by KT. All authors contributed to the design of the study and the analysis plan. KA carried out the data collection, analysed the data and wrote the initial draft of the manuscript. KT and ER reviewed and edited manuscript drafts. All authors read and approved the final article.

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Ethical statement

The study received ethical approval from the City, University of London Psychology Department Research Ethics Committee (approval number ETH2122-0935).

Declaration of competing interest

ER has previously received research funding from Unilever and the American Beverage Association. The authors have no other conflict of interest to declare.

Data availability

The study data is available on the Open Science Framework at https://osf.io/c5qug/.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2023.107131.

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