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The effects of mindful eating on food consumption over a half-day period.

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Abstract

This study examined the effects of a key feature of mindful eating (paying attention to the sensory properties of food) on calorie and macronutrient intake over a half-day period. Female participants (*n* = 60) were given a 635 kcal lunch of sandwiches, crisps and grapes. Those allocated to an experimental condition were asked to attend to the sensory properties of the food. After lunch, all participants were given 908 kcal of three energy dense sweet snack foods and asked to taste and rate them on several dimensions. Unknown to participants, the amounts of all foods consumed were recorded. Before they left the laboratory, participants in the experimental group were also asked to continue to pay attention to the sensory properties of their food for the rest of the day. At the end of the day all participants logged onto a website where they completed a suspicion probe and surprise online food recall measure to assess food intake outside the laboratory. Data from participants who guessed their eating was being measured were excluded. There were no differences between the experimental and control groups in terms of calories consumed during the taste test (166 versus 144 kcal respectively; *n* = 48) or across the entire half-day period (1456 versus 1343 kcal respectively; *n* = 44). There were also no differences in total intake of saturated fat, added sugar or fibre. The results fail to support other research that has shown reductions in food intake following mindful eating. This highlights the need to identify underlying mechanisms of action to better understand when this strategy is, and is not, likely to influence diet. Pre-registration: osf.io/f4x2m

Keywords: mindfulness; mindful eating; diet; calories; memory

1. Introduction

Mindfulness is increasingly being used to aid weight management. However, evidence of its effects is still lacking. For example, Olson and Emery (2015) reviewed 19 mindfulness-based interventions for weight loss and concluded that although 13 of these brought about significant reductions in weight, it was not clear whether these effects were driven by increases in mindfulness.

A key difficulty in establishing the effects of mindfulness for weight management stems from the fact that interventions typically also involve non-mindfulness components, such as group workshops, information about healthy eating or exercises designed to increase motivation (Tapper, 2017). This is compounded by the fact that it is difficult to convincingly show that levels of mindfulness have increased as a result of the intervention, as self-report measures of mindfulness are prone to bias and there are no alternative, objective measures that can be used (Tapper, 2017; see also Grossman, 2011; Kruger & Dunning, 1999). As such, it can be difficult to establish the extent to which the mindfulness components of an intervention are responsible for any effects.

An additional challenge is that the concept of mindfulness itself incorporates different elements. Mindfulness can be defined as 'awareness that emerges through paying attention on purpose, in the present moment, and non-judgmentally to the unfolding of experience moment by moment' (Kabat-Zinn, 2003). When it comes to eating, this could mean a number of different things, including paying attention to the sensory properties of food as one eats, paying attention to feelings of hunger and satiety, paying attention to internal and external cues that elicit eating or the desire to eat, or taking a non-judgemental attitude to any of these thoughts, feelings or bodily sensations. Each of these strategies could have quite different effects on eating behaviour (Tapper, 2017; Tapper, 2018). Recent research on the concept of mindful eating reinforces the idea that people may be mindful in different ways. For example, the extent to which people report paying attention to the sensory properties of their food is only moderately correlated with the extent to which they report paying attention

to feelings of hunger and satiety (Winkens et al., 2018). This means that the effects of mindfulness-based weight management interventions may be inconsistent, depending on the particular exercises they emphasise and/or the ways in which individuals apply mindfulness to their eating.

Given the above, there is a need for more experimental work to (a) test the effects of specific, clearly defined mindfulness-based strategies, and (b) employ carefully controlled methods to rule out the influence of other factors unrelated to mindfulness. The present study is one such experiment that examined the effects of paying attention to the sensory properties of food whilst eating.

Attending to the sensory properties of food whilst eating is an essential feature of mindful eating (Winkens et al., 2018). As well as being described as mindful eating it has also been referred to as 'attentive eating', and 'focussed eating' (Robinson, Kersbergen & Higgs, 2014; Winkens et al., 2018). Of the experimental research published in this area, six assessments have found that this practice significantly reduces subsequent intake of high calorie foods in the laboratory (Arch et al., 2016; Higgs & Donohoe, 2011; Robinson, Kersbergen & Higgs, 2014; Allirot et al., 2018; Seguias & Tapper, 2018; Tapper, Seguias & Pathmanathen, 2018), and a seventh assessment has shown a trend in this direction (Cavanagh, Vartanian, Herman & Polivy, 2014). However, four assessments, including two that were pre-registered, have failed to find such effects, leading some researchers to question whether the effects may have been overestimated within the literature (Arch et al., 2016; Whitelock, Higgs, Brunstrom, Halford & Robinson, 2018; Whitelock, Gaglione, Davies-Owen & Robinson, 2019). More recently, a pre-registered 8-week attentive eating intervention (that included mindful eating as one of several intervention components) failed to find any effects on either weight loss or food intake over a 24-hour period (Whitelock, Kersbergen et al., 2019). This raises the possibility that the effects of mindful eating are not sustained over time, do not occur outside the laboratory setting, or are compensated for by increased consumption on other occasions.

The aim of the present study was to further explore the effects of paying attention to the sensory properties of food on subsequent consumption. It differed from previous studies by asking participants to eat a whole meal mindfully then examining effects on snack consumption almost immediately after. Previous research in which participants have eaten a whole meal in this way have only examined effects on consumption 2 to 3 hours later (Higgs & Donohoe, 2011; Robinson, Kersbergen & Higgs, 2014; Seguias & Tapper, 2018; Whitelock et al., 2018; Whitelock, Gaglione et al., 2019), though other research employing the consumption of smaller quantities of food has recorded immediate effects on subsequent consumption (Allirot et al., 2018; Arch et al., 2016; Tapper et al., 2018). In this study we aimed to reproduce what might be a more typical type of eating episode for participants, i.e. the opportunity to eat a high calorie food immediately after eating lunch. In light of previous research we predicted that, compared to a control condition, those who ate their lunch mindfully would consume fewer calories of an ad libitum snack presented to them after lunch.

A second aim of the research was to look at whether any effects extended to participants' eating outside the laboratory. We did this by asking all participants to complete a surprise food recall measure at the end of the day. We expected that, compared to the control condition, those allocated to the mindful eating condition would consume fewer calories over the entire half-day period.

Additionally, we were interested in whether the mindful eating strategy would impact upon participants' choice of food, as there is some evidence to suggest that mindful eating might encourage participants to make more healthy choices (Allirot et al., 2018; Arch et al., 2016). We achieved this by looking at participants' consumption of saturated fat, added sugar and fibre throughout the half-day period.

These three aims, together with their associated confirmatory hypotheses, were pre-registered at the Open Science Framework (Tapper & Seguias, 2019).

Finally, because this study included both observed (i.e. weighed) and recalled measures of food intake in the laboratory, it allowed us to explore the relationship between these two measures. Some research suggests that the effects of mindful eating on consumption occur because it improves memory for food that has been eaten which is then used to help guide later intake (Higgs & Donohoe, 2011). However, other research has failed to find support for this hypothesis (Robinson, Kersbergen & Higgs, 2014; Seguias & Tapper, 2018). Exploratory analysis conducted in this study examined whether the mindful eating manipulation improved recall of the types and quantities of food eaten.

2. Methods

2.1. Participants

Participants were 60 females with a mean age of 43.61 years (*SD* = 14.21, range = 18 to 72). English was a first language for 90% of the participants, mean self-reported body mass index (BMI) was 25.48 (*SD* = 5.96, range = 17.63 to 44.08) and 15% reported dieting to lose weight. Recruitment was conducted in association with the makers of a BBC television programme called 'Trust Me I'm a Doctor'. Advertising for the study stated it was a collaboration between the BBC and the university, investigating the relationship between personality and perception. Adverts were placed on the BBC's social media accounts and emailed to their local contacts. Adverts were also placed around the university buildings and handed as flyers to individuals in the university. Participants received 10 pounds sterling for taking part and to cover any travel expenses. To be considered for the study participants needed to be female, living in London, aged 18 years or over and fluent in English. (The study was restricted to females to limit the amount of variability in the quantities of food eaten, e.g. see Robinson et al., 2017.) Exclusion criteria were inability to comply with the study requirements, severe food allergies, allergies or restrictions in relation to the foods being used in the study and previous participation in any related study. Ethical approval was provided by the City, University of London Psychology Department Research Ethics Committee. The target sample size was 60 (30 per

condition). This was informed by Seguias and Tapper (2018) and assumed a difference in consumption of 70kcal (SD = 90) between the two conditions on ad libitum snack intake in the laboratory. The method and analysis strategy were pre-registered with the Open Science Framework (osf.io/f4x2m).

2.2. Study design, randomisation and blinding

The study employed a between groups, double-blind design in which participants were randomised to one of two conditions: provision of standard instructions plus instructions to eat mindfully (experimental condition) or provision of standard instructions (control condition). The first author (KT) generated the randomisation sequence which used a 1:1 allocation ratio and a block size of 2. She then put the appropriate instructions for participants into sequentially numbered opaque sealed envelopes. The second author (LS), who was responsible for participant recruitment and testing, was blind to both the randomisation sequence and participant condition. (In approximately 8 instances researcher blinding failed either after lunch was provided or after the snack was provided due to participants leaving instructions out of the envelope.) Blinding of participants was checked at the end of the study using a funnelled suspicion probe (see sections 2.6 and 3).

2.3. Experimental manipulation

All participants received a sealed envelope with their lunch, that they were asked to open before eating their lunch. It contained written instructions that told them to eat as much lunch as they liked, informed them that the researcher would return in 10 minutes and asked them to place the instructions back in the envelope once they had finished eating. For those allocated to the experimental condition, these instructions also asked them to pay attention to the sensory properties of the food as they ate and described ways in which they might do this, for example by noticing the colour, smell, taste, texture and sound of the food.

Before leaving the laboratory, all participants received a second sealed envelope that they were asked to open as soon as they had left. This second envelope

contained details of a username and password and asked them to log into a website half an hour before they went to bed, to answer some additional questions. For those allocated to the experimental condition, these instructions also asked them to continue to pay attention to the sensory properties of their food for the remainder of the day. Again, the instructions described ways in which they might do this. Copies of the instructions can be viewed in the supplementary information.

2.4. Lunch and bogus taste test

The lunch provided to participants contained approximately 635 kcal and consisted of one Sainsbury's cheese and tomato sandwich on malted bread (165 g; 434 kcal), Walkers ready salted crisps (32.5 g; 171 kcal) and 10 red grapes (approximately 50 g; 30 kcal). These foods were provided to participants on a single plate along with a glass and jug of water. They were left alone for 10 minutes to eat lunch. All foods were weighed both before and after consumption to determine the amounts eaten.

The snack foods were provided after lunch as part of a bogus taste test and consisted of three separate 60 g servings of Sainsbury's milk chocolate digestive biscuits (299 kcal), Cadbury milk chocolate biscuit fingers (310 kcal) and Maryland mini chocolate chip cookies (299 kcal). These foods were broken into smaller pieces to reduce the chances of participants monitoring the amount they were eating. They were served on three individual plates labelled as 'A', 'B; and 'C' alongside a sheet of questions asking them to taste and rate each of the foods in terms of sweetness, saltiness and liking. These questions were used to prompt participants to taste the foods but reduce the chances of them guessing that their consumption was being measured, as this knowledge has been shown to supress intake (Robinson, Kersbergen, Brunstrom & Field, 2014). Participants were also told they could eat as much of the snacks as they liked once they had finished the rating task as any leftovers would be thrown away. They were left alone for 5 minutes to complete this task. All foods were weighed both before and after consumption to determine the amounts eaten. The bogus taste test is a widely

244 employed method of assessing food consumption in the laboratory that has been
245 shown to have good validity and sensitivity (Robinson et al., 2017).
246
247 **2.5. Food recall measure**
248 Self-reported food intake was assessed using a computerised multiple-pass 24-
249 hour recall measure called INTAKE24 (Simpson et al., 2017). The measure first
250 asks users to list all foods and drinks consumed from the time of waking up. It
251 then asks for further details of each item reported (such as type or brand),
252 requests details of serving size and any leftovers, and provides prompts for
253 additional items (such as sugar added to tea) or items that may have been
254 forgotten (e.g. where no drink is reported with lunch). Finally, the user is asked
255 to review all items reported to ensure that the details are correct and nothing
256 has been missed. The INTAKE24 measure has shown good agreement with
257 interviewer-led 24-hour recalls, in terms of both energy and macronutrient
258 intake (Bradley et al., 2016).
259
260 **2.6. Procedure**
261 Participants who contacted the BBC, and met the inclusion criteria, were asked
262 to provide their name and contact details, which were then passed on to the
263 second author (LS) who sent them an information sheet about the study and
264 contacted them the following day to answer any additional questions they had,
265 check exclusion criteria and, where relevant, book an appointment for them to
266 take part. Where participants contacted LS directly, she also assessed inclusion
267 criteria.
268
269 Participants were asked to attend an appointment at the university at either
270 12pm, 12.45pm or 1.30pm and asked not to eat lunch beforehand. Upon arrival,
271 participants were provided with lunch as well as the first sealed envelope. After
272 10 minutes the researcher (LS) returned to the laboratory and cleared away the
273 lunch. The participant was then provided with a questionnaire booklet
274 containing the Reinforcement Sensitivity Theory Personality Questionnaire (Corr
275 & Cooper, 2016) and instructions and materials for sorting coloured tiles into
276 colour categories. These served as both filler tasks and as a way of reducing the

chances that participants would guess the study aims and their group allocation. The researcher left the participant for 10 minutes to complete these tasks before returning to administer the bogus taste test. After the taste test participants were given the second envelope and reminded to open it as soon as they left the laboratory.

When participants logged on to the website in the evening they completed a funnelled suspicion probe followed by the food recall measure. They were then informed of the real aims of the study and asked to provide or withhold consent for the use of the food intake data collected in the laboratory. After this they were presented with three 9-point rating scales (anchored by 'Not at all' and 'Nearly all the time') and rated the extent to which they had payed attention to the sight, smell, taste, texture and sound of the food they had eaten (a) at lunch, (b) during the taste test, and (c) during the rest of the day. They then indicated whether they intended to eat or drink anything else before going to bed, and provided details of their age, first language, weight and height and whether or not they were dieting to lose weight. The researcher called them the next morning at a pre-arranged time to answer any further questions they had.

3. Results

3.1. Data screening

KT coded the data from the suspicion probe, prior to receiving the data on food consumption, from either the laboratory or food diary measures. According to the suspicion probe data, 11 participants guessed that food consumption was being measured (7 in the experimental group, 4 in the control group) and these participants were excluded from data analysis. One participant could not access the online part of the study so failed to provide consent for the use of the consumption data and was also excluded. An additional four participants either failed to complete the food diary section of the online questionnaire or reported on food consumed on a different day. This left a total of 48 participants for the

assessment of consumption data in the laboratory and 44 for the assessment of intake during the half-day period.

3.2. Participant characteristics

As shown in Table 1, participants were well matched across the two conditions in terms of first language and BMI. Participants in the control group were slightly older than those in the experimental group and there were more participants in the control group who reported dieting to lose weight.

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

Characteristic	Experimental (*n* = 23)	Control (*n* = 25)
Age (*M, SD*)	41.96 (14.63)	48.24 (13.29)
Percentage first language English	91%	92%
Percentage dieting to lose weight	0%	20%
Self reported BMI (*M, SD*)*	24.85 (6.11)	25.92 (6.65)

**n* = 19 and 24 respectively due to missing data.

3.3. Manipulation check

Table 2 shows the mean levels of mindful eating reported by participants.

Table 2. Mean (*SD*) ratings by participants of the extent to which they paid attention to the sensory properties of their food at different points in the study.

Eating occasion	Experimental (*n* = 23)	Control (*n* = 25)
Lunch	8.09 (1.16)	5.48 (2.18)
Taste test	8.00 (1.31)	6.76 (2.09)
Rest of day	6.00 (2.17)	4.76 (2.11)

Ratings were made on a scale of 1-9.

A 2(condition) x 3(eating occasion) mixed ANOVA showed a main effect of condition; those in the experimental group reported significantly more mindful eating than those in the control group, $F(1, 46) = 15.44$, $p < .001$. There was also a significant interaction between time and condition, $F(1, 46) = 5.82$, $p = .02$ with

follow-up t-tests showing that the experimental group ate significantly more mindfully during lunch, $t(46) = 5.01$, $p < .001$, and during the taste test, $t(46) = 2.44$, $p = .02$, but not during the rest of the day, $t(46) = 2.00$, $p = .051$.

3.4. Confirmatory analyses: effects on calories consumed during the taste test and throughout the half-day period.

Calories consumed at lunch and during the taste test were computed using the weight of food consumed by each participant and the caloric information from the food packaging. Calories consumed during the rest of the day were obtained from the INTAKE24 software that automatically calculates calories from the foods and portion sizes reported by participants. These figures are shown in Table 3.

Table 3. Mean (*SD*) calories of food consumed by participants in the experimental and control conditions during lunch, the taste test and throughout the rest of the day.

Eating occasion	Experimental	Control
Lunch	434 (110)	436 (130)
Taste test	166 (105)	144 (96)
Rest of day	839 (496)	759 (403)
Total	1456 (560)	1343 (445)

$n = 23$ and 25 in the experimental and control groups respectively for lunch and the taste test, 21 and 23 for rest of day and total.

Two independent t-tests showed that there were no significant differences in consumption during the taste test, $t(46) = 0.76$, $p = .45$ or throughout the entire half-day period, $t(42) = 0.75$, $p = .46$.

3.5. Confirmatory analyses: effects on macronutrients consumed throughout the half-day period.

Grams of saturated fat, added sugar (i.e. non milk extrinsic sugars) and fibre consumed by each participant at lunch and during the taste test were computed for each participant using the weight of food they consumed and the nutritional information from the food packaging. These figures were then added to the figures provided by INTAKE24 in relation to foods consumed after participants had left the laboratory. These totals for the half-day period are shown in Table 4.

Table 4. Mean (*SD*) grams of macronutrients consumed by participants in the experimental and control conditions throughout the half-day period.

Macronutrient	Experimental (*n* = 21)	Control (*n* = 23)
Saturated fat	26 (12)	23 (9)
Added sugar	42 (32)	39 (31)
Fibre	12 (4)	12 (5)

A 2-way MANOVA showed no effect of condition on saturated fat, $F(1, 42) = 1.08$, $p = .31$, added sugar, $F(1, 42) = 0.05$, $p = .82$, or fibre, $F(1, 42) = 0.22$, $p = .64$.

3.6. Exploratory analyses: relationship between self-reported mindful eating and consumption

At lunchtime and during the taste test, those who reported paying more attention to the sensory properties of their food as they ate consumed fewer calories, but these correlations were not statistically significant; $r = -.14$, $p = .33$ for lunch, $r = -.17$, $p = .24$ for the taste test. There was no association between self-reported mindful eating and amounts consumed outside the laboratory, $r = -.04$, $p = .79$.

3.7. Exploratory analyses: effect of condition on the relationship between observed and recalled consumption in the laboratory

A total of 53 participants reported on the lunch they had consumed in the laboratory in the food recall measure. Of these, 27 (51%) failed to include the

biscuits and cookies consumed in the taste test. These participants did not eat significantly less compared to those who included them in their recall (M = 123 kcal, SD = 85 compared to M = 172 kcal, SD = 105 respectively; $t(51) = 1.87$, p = .067) and the amounts they consumed were not negligible (range = 30–278 kcal, Mdn = 90 kcal). Failing to recall the biscuits/cookies also did not seem to be influenced by condition since there was no significant difference in the proportions omitting them in the two groups (46% in the experimental group, 56% in the control group; $X^2(1) = 0.48$, $p = 0.49$). To examine differences in memory for amounts of food consumed, calories consumed were calculated for each of the four foods according to the weighed measure and according to the portion sizes participants reported in the recall measure. Comparisons of these measures again showed no evidence that those in the experimental group had a better memory for the food they had eaten compared to those in the control group (Table 5).

Table 5. Mean (SD) differences[a] in calories consumed according to observed and recalled measures, and correlations (r_s) between observed and recalled measures, in the experimental and control groups, for each of the four foods consumed in the laboratory.

Food	Experimental[b]	Control[c]
Sandwich		
Difference	262 (329)	246 (149)
Correlation	-.07	.10
Grapes		
Difference	-3 (16)	-8 (19)
Correlation	.36	.35
Crisps		
Difference	18 (69)	-6 (61)
Correlation	.55	.68
Biscuits/cookies		
Difference	2 (133)	46 (155)
Correlation	.17	.73

[a]A positive score indicates that calories were overestimated according to the recall measure, a negative score that they were underestimated.
[b]n = 27 for the sandwich, 28 for the grapes and crisps and 15 for the biscuits/cookies (one participant was excluded from the sandwich data as they failed to include a portion size estimate).
[c]n = 25 for the sandwich, grapes and crisps, 11 for the biscuits/cookies.

3.8. Sensitivity analysis

When analyses were repeated excluding the five dieters in the control group, the pattern of effects remained unchanged (control group taste test intake: M = 153 kcal, SD = 97; control group rest of day intake: M = 765 kcal, SD = 393). When analyses were repeated using the entire sample, the results showed that during the rest of day, the experimental group reported eating significantly more mindfully compared to the control group, $t(57) = 3.11$, $p = .003$ (see section 3.3), and that those who reported paying more attention to the sensory properties of their food during the taste test ate significantly fewer calories, $r = -.27$, $p = .04$ (see section 3.6). The pattern of effects for all other analyses remained unchanged.

4. Discussion

The results showed no effect of mindful eating at lunch on the amount of high calorie snack food consumed immediately after lunch. These findings contrast with other research that has found that mindfully eating lunch reduces snack intake 2-3 hours later (Higgs & Donohoe, 2011; Robinson, Kersbergen & Higgs, 2014; Seguias & Tapper, 2018) and that mindfully eating a smaller quantity of food reduces immediate consumption of a second food (Arch et al. 2016; Allirot et al., 2018; Tapper et al., 2018). However, the results are consistent with other research that has failed to find effects (Arch et al., 2016; Whitelock et al., 2018; 2019). It is possible that the studies showing significant effects represent false positives, particularly as these studies tend to have smaller sample sizes, which are more likely to lead to false positives. However, it is also possible that the effect only occurs under certain conditions. If so, it would be important to identify underlying mechanisms of action as this would allow for a better understanding of when mindful eating reduces intake and when it does not.

In line with previous research (Robinson, Kersbergen & Higgs, 2014; Segiuas & Tapper, 2018), the current study found no evidence to support the hypothesis that mindful eating influences intake by improving memory for foods eaten. An

alternative explanation for the significant effects reported in the literature is that paying attention to the sensory properties of food increases the cognitive accessibility of goals that are relevant to that food, such as weight loss or healthy eating related goals, which may in turn reduce consumption of high calorie foods or of the total amount of food eaten. Indeed, there is some evidence to show that mindfulness can increase the cognitive accessibility of weight loss related goals (Tapper & Ahmed, 2018). This may explain the absence of effects in the current study; if participants were not motivated to eat more healthily or lose weight, such goals would not have been activated. This interpretation is supported by the fact that only a relatively small proportion of participants (10%) reported dieting to lose weight and these participants all fell into the control group. Future research may benefit from including measures of restrained eating and motivation to eat healthily to explore this suggestion.

Another possible explanation is that mindful eating reduces intake only where it slows down the rate of eating. A substantial body of research shows that slowed eating and/or increased oral processing is associated with reduced intake (Hollis, 2018; Krop et al., 2018; Robinson, Almiron-Roig et al., 2014; Miquel-Kergoat, Azais-Braesco, Burton-Freeman & Hetherington, 2015). However, rate of eating may be influenced by a wide range of different variables including individual differences, food and meal properties and motivational factors such as hunger and liking for the food (Almiron-Roig et al., 2015; Bobroff & Kissileff, 1986; Hill & McCutcheon, 1984; Llewellyn, van Jaarsveld, Boniface, Carnell & Wardle, 2008; Suh & Jung, 2016; Wilkinson et al., 2016; Zhu, Hsu & Hollis, 2013). Thus there may have been floor effects in the rate at which participants ate the snack foods in the current study if they were not hungry (having just eaten lunch) and were taking part in the research in a relatively relaxed fashion. It is possible that certain groups of participants (such as students who complete multiple studies) try to complete the research in a more efficient manner and therefore tend to eat at a faster rate. As such, future research may benefit from either controlling for, or measuring, hunger and speed of eating in order to explore these possibilities.

The results of the current study also failed to find any effects of mindful eating on the quantities or types of foods consumed across the half-day period. However, given that those in the experimental group did not report eating significantly more mindfully outside the laboratory compared to those in the control group, it is difficult to draw any firm conclusions from these data. Instead, the research raises the additional question of how best to motivate individuals to apply the mindful eating strategy in their daily lives. It is possible that certain groups of people (such as those trying to lose weight) would be more intrinsically motivated to eat mindfully if they believed it would benefit them. But it is also possible that sustaining motivation for mindful eating would be easier if individuals were only advised to apply it in certain situations, such as when they were hungry or when eating particular foods. Again, identifying underlying mechanisms could help inform such advice.

The results from the food recall measure also raise the question of whether this type of measure is sensitive enough to detect any changes in diet associated with mindful eating, since such changes are likely to be relatively small. In particular, more than half of participants failed to record the snack they had eaten in the laboratory, even though the energy content of this snack averaged over 100 kcal, representing around 5% of a woman's average energy requirements. Physiological measures, such as changes in weight, may ultimately be a better test of the effect of mindful eating, though this would require sustained application of the strategy by participants over much longer periods of time.

Another important limitation of the study was the sample size, which was relatively small and showed an imbalance between conditions in terms of both age and whether participants were dieting to lose weight. It was also smaller than the target sample size of 60. Small sample sizes are more likely to result in false positive or false negative results so future research would benefit from recruiting larger numbers of participants.

Finally, it is important to distinguish between the effects of paying attention to the sensory properties of food and the effects of eating while distracted, for

example whilst watching television. There is some evidence that the latter increases intake, possibly by disrupting memory for food eaten (Higgs, 2015; Oldham, Hardman, Nicoll, Rogers & Brunstrom, 2011) as well as increasing reliance on behaviour that is more automatic in nature (Neal, Wood, Wu & Kurlander, 2011). As such, mindful eating may help reduce consumption where it prompts people to reduce the extent to which they eat whilst engaged in other activities. This is slightly different from the focus of the current study which examined whether actively attending to the sensory properties of food has any benefits. An interesting question for future research may be to look at whether people could be encouraged to pay more attention to the sensory properties of their food even when engaged in other activities, such as working or watching television, and whether this might help reduce the extent to which distraction increases food intake.

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Author contributions

The study was conceived and designed by both authors. LS carried out the data collection and KT analysed the data. KT wrote the paper and both authors read and approved the final version.

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Conflict of interest

Conflicts of interest: none

References

Allirot, X., Miragall, M., Perdices, I., Baños, R. M., Urdaneta, E., & Cebolla, A. (2018). Effects of a brief mindful eating induction on food choices and energy intake: external eating and mindfulness state as moderators. *Mindfulness*, *9*(3), 750-760.

Almiron-Roig, E., Tsiountsioura, M., Lewis, H. B., Wu, J., Solis-Trapala, I., & Jebb, S. A. (2015). Large portion sizes increase bite size and eating rate in overweight women. *Physiology & Behavior*, *139*, 297-302.

Arch, J.J., Brown, K.W., Goodman, R.J., Della Porta, M.D., Kiken, L.G. & Tillman, S. (2016). Enjoying food without caloric cost: the impact of brief mindfulness on laboratory eating outcomes. *Behaviour Research and Therapy, 79,* 23-34.

Bobroff, E.M. & Kissileff, H.R. (1986). Effects of changes in palatability on food intake and the cumulative food intake curve in man. *Appetite, 7(1),* 85–96.

Bradley, J., Simpson, E., Poliakov, I., Matthews, J., Olivier, P., Adamson, A., & Foster, E. (2016). Comparison of INTAKE24 (an online 24-h dietary recall tool) with interviewer-led 24-h recall in 11–24 year-old. *Nutrients*, *8*(6), 358.

Cavanagh, K., Vartanian, L.R., Herman, C.P. & Polivy, J. (2014). The effect of portion size on food intake is robust to brief education and mindfulness exercises. *Journal of Health Psychology, 19,* 730–739.

Corr, P.J. & Cooper, A.J. (2016). The Reinforcement Sensitivity Theory of Personality Questionnaire (RST-PQ): Development and validation. *Psychological Assessment* 28 (11), 1427-1440.

Grossman, P. (2011). Defining mindfulness by how poorly I think I pay attention during everyday awareness and other intractable problems for psychology's
(re)invention of mindfulness: comment on Brown et al. (2011). *Psychological Assessment, 23,* 1034-1040.

Higgs, S. (2015). Manipulations of attention during eating and their effects on later snack intake. *Appetite*, *92*, 287-294.

Higgs, S. & Donohoe, J.E. (2011). Focusing on food during lunch enhances lunch memory and decreases later snack intake. *Appetite, 57,* 202-206.

Hill, S.W. & McCutcheon, N.B. (1984). Contributions of obesity, gender, hunger, food preference, and body size to bite size, bite speed, and rate of eating. *Appetite*, *5*(2), 73-83.

Hollis, J. H. (2018). The effect of mastication on food intake, satiety and body weight. *Physiology & Behavior*, *193*, 242-245.

Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: Past, present, and future. *Clinical Psychology: Science and Practice, 10,* 144–156.

Krop, E. M., Hetherington, M. M., Nekitsing, C., Miquel, S., Postelnicu, L., & Sarkar, A. (2018). Influence of oral processing on appetite and food intake–A systematic review and meta-analysis. *Appetite*, *125*, 253-269.

Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: how difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology*, *77*(6), 1121.

Llewellyn, C. H., Van Jaarsveld, C. H., Boniface, D., Carnell, S., & Wardle, J. (2008). Eating rate is a heritable phenotype related to weight in children. *The American Journal of Clinical Nutrition*, *88*(6), 1560-1566.

Miquel-Kergoat, S., Azais-Braesco, V., Burton-Freeman, B., & Hetherington, M. M. (2015). Effects of chewing on appetite, food intake and gut hormones: A systematic review and meta-analysis. *Physiology & Behavior*, *151*, 88-96.

606 Neal, D. T., Wood, W., Wu, M., & Kurlander, D. (2011). The pull of the past:
607 When do habits persist despite conflict with motives? *Personality and Social*
608 *Psychology Bulletin*, *37*(11), 1428-1437.
609 Oldham-Cooper, R. E., Hardman, C. A., Nicoll, C. E., Rogers, P. J., &
610 Brunstrom, J. M. (2010). Playing a computer game during lunch affects fullness,
611 memory for lunch, and later snack intake. *The American Journal of Clinical*
612 *Nutrition*, *93*(2), 308-313.
613 Olson, K.L. & Emery, C.F. (2015). Mindfulness and weight loss: a
614 systematic review. *Psychosomatic Medicine, 77,* 59-67.
615 Robinson, E., Almiron-Roig, E., Rutters, F., de Graaf, C., Forde, C. G., Tudur
616 Smith, C., ... & Jebb, S. A. (2014). A systematic review and meta-analysis
617 examining the effect of eating rate on energy intake and hunger. *The American*
618 *Journal of Clinical Nutrition*, *100*(1), 123-151.
619 Robinson, E., Haynes, A., Hardman, C. A., Kemps, E., Higgs, S., & Jones, A.
620 (2017). The bogus taste test: Validity as a measure of laboratory food intake.
621 *Appetite, 116,* 223-231.
622 Robinson, E., Kersbergen, I., Brunstrom, J. M., & Field, M. (2014). I'm
623 watching you. Awareness that food consumption is being monitored is a demand
624 characteristic in eating-behaviour experiments. *Appetite*, *83*, 19-25.
625 Robinson, E., Kersbergen, I., & Higgs, S. (2014). Eating 'attentively'
626 reduces later energy consumption in overweight and obese females. *British*
627 *Journal of Nutrition*, *112*(4), 657-661.
628 Seguias, L., & Tapper, K. (2018). The effect of mindful eating on
629 subsequent intake of a high calorie snack. *Appetite*, *121*, 93-100.
630 Simpson, E., Bradley, J., Poliakov, I., Jackson, D., Olivier, P., Adamson, A., &
631 Foster, E. (2017). Iterative development of an online dietary recall tool:
632 INTAKE24. *Nutrients, 9(2),* 118.
633 Suh, H. J., & Jung, E. Y. (2016). Effect of food service form on eating rate:
634 meal served in a separated form might lower eating rate. *Asia Pacific Journal of*
635 *Clinical Nutrition*, *25*(1), 85-88.
636 Tapper, K. (2017). Can mindfulness influence weight management related
637 eating behaviors? If so, how? *Clinical Psychology Review, 53,* 122-134.

638 Tapper, K. (2018). Mindfulness and craving: effects and
639 mechanisms. *Clinical Psychology Review, 59,* 101-117.
640 Tapper, K. & Ahmed, Z. (2018). A mindfulness-based decentering
641 technique increases the cognitive accessibility of health and weight loss related
642 goals. *Frontiers in Psychology, 9,* 587.
643 Tapper, K. & Seguias, L. (2019, January 15). Mindful eating over a half-day
644 period. Retrieved from osf.io/f4x2m
645 Tapper, K., Seguias, L. & Pathmanathan, M. (2018). The effects of mindful
646 eating on desire and consumption. *Appetite, 123,* 450.
647 Whitelock, V., Gaglione, A., Davies-Owen, J., & Robinson, E. (2019).
648 Focused attention during eating enhanced memory for meal satiety but did not
649 reduce later snack intake in men: A randomised within-subjects laboratory
650 experiment. *Appetite*, *136*, 124-129.
651 Whitelock, V., Higgs, S., Brunstrom, J. M., Halford, J. C., & Robinson, E.
652 (2018). No effect of focused attention whilst eating on later snack food intake:
653 Two laboratory experiments. *Appetite*, *128*, 188-196.
654 Whitelock, V., Kersbergen, I., Higgs, S., Aveyard, P., Halford, J. C., &
655 Robinson, E. (2019). A smartphone based attentive eating intervention for
656 energy intake and weight loss: results from a randomised controlled trial. *BMC*
657 *Public Health*, *19*(1), 611.
658 Wilkinson, L. L., Ferriday, D., Bosworth, M. L., Godinot, N., Martin, N.,
659 Rogers, P. J., & Brunstrom, J. M. (2016). Keeping Pace with Your Eating: Visual
660 Feedback Affects Eating Rate in Humans. *PloS One*, *11*(2), e0147603.
661 Winkens, L. H., van Strien, T., Barrada, J. R., Brouwer, I. A., Penninx, B. W.,
662 & Visser, M. (2018). The Mindful Eating Behavior Scale: Development and
663 psychometric properties in a sample of Dutch adults aged 55 years and
664 older. *Journal of the Academy of Nutrition and Dietetics*, *118*(7), 1277-1290.
665 Zhu, Y., Hsu, W. H., & Hollis, J. H. (2013). The impact of food viscosity on
666 eating rate, subjective appetite, glycemic response and gastric emptying
667 rate. *PLoS One*, *8*(6), e67482.
668