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ORIGINAL PAPER

Effects of a Brief Mindful Eating Induction on Food Choices and Energy Intake: External Eating and Mindfulness State as Moderators

Xavier Allirot[1] · **Marta Miragall**[2] · **Iñigo Perdices**[1] · **Rosa Maria Baños**[2,3] · **Elena Urdaneta**[1] · **Ausias Cebolla**[2,3]

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Abstract Mindfulness techniques have been shown to have protective effects on eating. However, no studies have been conducted on the effect of a single mindful eating (ME) induction on subsequent food choices and intake, and the way eating behaviors and the mindfulness state might moderate this effect. The objectives of the present study were to assess (1) the effect of an ME induction on food choices, intake, liking, and appetite, and (2) whether eating behaviors and the mindfulness state moderate the effect on intake. Seventy adult women (35.27 ± 1.27 years old; body mass index 22.79 ± 0.44 kg/m^2) were invited to a tasting session. Participants in the mindful group received the instruction to taste the foods in a mindful manner (without meditation training). Participants in the control group were instructed to taste the foods with no specific recommendations. Afterwards, participants were offered an individual buffet-style snack containing the foods previously tasted. During this snack, the mindful group showed a reduced number of high-energy-dense food items eaten (p = .019) and a decreased energy intake (p = .024), compared to controls. No differences were found between groups on appetite and liking. Moderation analyses showed that the ME induction was able to reduce the total number of food items and energy intake in participants who combined higher levels of external eating and lower levels of mindfulness state. Results encourage the promotion of ME, particularly in external eaters with low mindfulness state levels, and they support ME as a strategy to promote healthy eating.

Keywords Mindful eating · Mindfulness · Food intake · Food choices · Eating behaviors

Introduction

In a context with a high prevalence of overweight and obesity (NCD Risk Factor Collaboration 2016), the promotion of healthy food choices is considered highly important. A large number of strategies have been proposed and evaluated to direct food choices toward healthier foods and reduce the intake of less healthy foods (Grieger et al. 2016). The use of mindfulness techniques to promote healthy eating habits and aid in weight regulation has recently received considerable attention (Mantzios and Wilson 2015). Kabat-Zinn (2003) defined mindfulness as the awareness that emerges through purposely and non-judgmentally paying attention to the present moment. When this tendency is related to eating behaviors, as in the awareness of physical signals of hunger or fullness and environmental or emotional triggers to eat, it is called mindful eating (ME) (Kristeller and Wolever 2011).

Eating behaviors are shaped by a complex interplay of physiological, psychological, social, and genetic factors that influence meal timing, quantity of food intake, and food preferences (Grimm and Steinle 2011). Several maladaptive types of eating behaviors have been identified. The present paper focuses on the three types of eating behaviors identified by van Strien et al. (1986): (a) emotional eating (eating in response to specific emotional states, mainly negative emotions); (b) external eating (eating in response to external cues,

✉ Xavier Allirot
xallirot@bculinary.com

[1] Basque Culinary Center, BCC INNOVATION, Paseo Juan Avelino Barriola, 101 – 20009 San Sebastián, Spain

[2] Department of Personality, Evaluation and Psychological Treatment, Universitat de València, Valencia, Spain

[3] CIBERObn Ciber Fisiopatologia de la obesidad y la nutrición, Instituto Carlos III, Santiago de Compostela, Spain

such as the smell or appearance of food, regardless of internal signals of hunger and fullness); and (c) restrained eating (eating less than the desired amount in order to lose or maintain weight). Eating behaviors such as emotional eating show gender differences (Larsen et al. 2006), influence food selection (van Strien et al. 2013), and are directly related to dietary patterns and body mass index (BMI) (Baños et al. 2014).

Mindfulness can be trained through mindfulness-based interventions (MBI), and it has shown benefits in alleviating symptoms, both mental and physical, in the adjunct treatment of cancer, cardiovascular disease, chronic pain, depression, and anxiety disorders, and in prevention in a healthy population (Gotink et al. 2015). Regarding eating behaviors, dispositional mindfulness (measured through a questionnaire) has been positively associated with healthier eating behaviors (Jordan et al. 2014) in a morbidly obese sample (Ouwens et al. 2015) and in individuals with type 1 and 2 diabetes (Tak et al. 2015). Higher levels of dispositional mindfulness have also been related to less emotional eating (Pidgeon et al. 2013) or less uncontrolled eating (Lattimore et al. 2011) in non-clinical samples. Furthermore, MBI have been shown to be effective in increasing discrimination between different types of hunger (Baer et al. 2005), improving reactions to craving (Alberts et al. 2012), enhancing self-regulation in environments where one is regularly exposed to attractive stimuli (Papies et al. 2012), and providing overall help in weight regulation (Dalen et al. 2010). In experimental contexts, brief mindfulness inductions have also shown beneficial effects. They can help in resisting chocolate temptation (Jenkins and Tapper 2014), decreasing food intake, even when there is craving (Fisher et al. 2016), and reducing unhealthy food consumption (Marchiori and Papies 2014; Papies et al. 2015).

The techniques used in these MBI or brief inductions are mostly based on meditation, body scan, and mindful attention induction. However, Mantzios and Wilson (2015) suggested that one way to make MBI or inductions more behavior-relevant would be to remove the need for meditation and focus strictly on ME. This proposal is supported by the results of Beshara et al. (2013), who demonstrated that ME fully mediated the negative association between everyday mindfulness and serving size and might have a greater influence on serving size than daily mindfulness. Furthermore, the impact of a short ME induction on food selection has been explored by Fisher et al. (2016). They showed that, after an ME induction, hunger did not change, but it was significantly higher in a control group, with an increase in the number of snacks eaten. Along the same lines, Arch et al. (2016) found that a short ME induction increased the enjoyment of the food and led to the consumption of lower calorie foods.

To our knowledge, few studies have analyzed the short-term effects of a brief ME induction on subjective appetite, food choices, energy intake, and food liking, and explored their relationships with eating behaviors and mindfulness state. Hence, the first aim of the current investigation was to study the effects of a brief ME induction in adult women on subsequent subjective appetite, food choices, energy intake, and liking. The second aim was to study whether eating behaviors (external, emotional, and restrained eating) and mindfulness state could mediate the relationship between ME induction and food selection. The main hypothesis was that the ME group would decrease appetite and energy intake, increase food liking, and select less high-energy-dense food. The secondary hypothesis was that the mindfulness state and eating behaviors (external, emotional, and restrained eating) would moderate the effect on intake.

Method

Participants

Based on a previous study (Marchiori and Papies 2014), we calculated that a minimum sample size of fifty (50) participants was necessary to observe a significant difference of 100 kcal after a brief mindfulness exercise, with a significance level of 0.05 and a power of 80%. Adult women were recruited through advertisements. We only recruited women in order to minimize the effect of gender. After contacting the researchers by email or phone, the women completed a screening protocol through an online survey system (www.surveymonkey.com). The eligibility criteria for the present study were being a woman between 20 and 60 years old who claimed to like all the foods that would be presented during the experiment, did not have any allergies to these foods, and had breakfast daily. Ninety-six women contacted us and were sent the online screening survey, and 86 completed the survey. Finally, 70 adult women met the eligibility criteria and participated in the study. They had a mean age of 35.27 ± 1.27 years (mean ± standard error of the mean (SEM)) (ranging from 21 to 58) and a mean BMI of 22.79 ± 0.44 kg/m^2 (mean ± SEM, based on weight and height declared in the online screening survey) (ranging from 16.10 to 36.40).

All the participants gave their written consent to participate in the study. The study complied with the Second Declaration of Helsinki.

Procedure

Study Design

Experimental sessions were conducted at the Basque Culinary Center (BCC) in Spain. The study followed a between-subject design. Each participant participated in only one experimental session in the BCC. The sessions were carried out in groups of two participants (35 groups). Each of the 35 pairs was

randomly assigned to a condition: mindful or control. To cover the main objective and make sure the participants were blind to the conditions of the study, they were asked to arrive at the BCC at 10:30 am to participate in a tasting session of finger foods. Participants were asked to avoid vigorous activities and abstain from alcohol consumption the day before the experimental session. The day of the experimental session, they were also asked to have their usual breakfast, finish it before 9:00 am, and refrain from eating between breakfast and their appointment at the BCC. The experimental sessions were divided into three parts. The first part consisted of watching a 7-min mindful or control video. The second part was a tasting session of four finger foods performed in a mindful manner or in a control manner, depending on the condition. The third part was similar for both conditions and consisted of offering the participants an individual buffet-style snack while they answered electronic questionnaires.

Videos

After welcoming them, each pair of participants was led by a researcher to the room where the session would be delivered. Each pair of participants was invited to sit at the same table in front of a computer, where they were shown a 7-min video. In the mindful condition (n = 35), participants were shown an ME induction video consisting of a description of how they would have to taste the finger foods during the subsequent tasting session. The first step of the Mindful video was an oral explanation, and the second step was a visual demonstration. In this video, participants were shown how to taste foods, focusing on (1) sight (instruction: "observe the food as if you were seeing it for the first time"); (2) touch (instruction: "touch it and explore its texture"; (3) smell (instruction: "perceive olfactory sensations in each breath"; (4) taste and oral sensations, first without chewing and then while chewing the food slowly; and, finally, (5) ingestive effects while swallowing and immediate post-ingestive effects after swallowing (instruction: "be aware of how the food moves down into your stomach"). During the instructions, the word mindfulness or ME was avoided, and the participants were not aware of the study objective. In the control condition (n = 35), participants were shown a video presentation from the BCC, our University in gastronomic sciences. This video was mostly based on interviews held at the BCC, and it included very few food images.

Tasting Session

After the video, participants were invited by the researcher to sit at separate tables where they could not see each other or communicate. Each participant was offered four finger foods to taste in the following order: (1) a low-energy-dense (LED) savory food, (2) a high-energy-dense (HED) savory food, (3) a LED sweet food, and (4) a HED sweet food. The description of the four finger foods is available in Table 1.

In the mindful condition, participants were asked to taste the finger foods, following the instructions previously described. The same instructions appeared on a sheet of paper placed next to the foods on the table. In the control condition, no specific instructions were given about how to taste the four finger foods, except the order of consumption, which was written on a sheet of paper placed next to the foods on the table. Participants in both conditions were asked to eat all of the four finger foods.

Buffet-Style Snack

After the tasting session, participants in both conditions were asked to fill out electronic questionnaires related to non-relevant aspects of their eating habits, whether they liked cooking and how frequently they cooked, how frequently they ate at home or away from home. At the same time, they were given the opportunity to eat a free amount of the same four finger foods previously tasted. Four plates containing six of each finger food were placed on the table in front of each subject, next to the computer used to answer the electronic questionnaire. The participants were allowed 15 min for this task. Background lounge music was used to create a pleasant eating environment and keep participants from noticing whether the other participant in the room was still eating or not. After 15 min, the researcher removed the plates from the tables.

Measurements

The same measurements were performed in the mindful and control conditions, at the beginning of the experiment, before the video (T0), between the tasting session and the buffet-style snack (T1), and right after the buffet-style snack (T2). Some additional data were recorded the day after the experiment through an online survey (T3).

Subjective Appetite

Subjective appetite was assessed three times during the experimental session: at T0, T1, and T2. Electronic visual analogue scales (VAS) were used to assess feelings of hunger, fullness, and desire to eat. Each electronic VAS consisted of a 10-mm line presented on an HP 250 G2 (15.6″), anchored at the beginning and end by opposing statements such as "not hungry at all" and "extremely hungry", in response to the question: "how hungry do you feel?" Participants were asked to click on the line that best matched how they were feeling at the time. The terminology was orally explained to the participants: 'hunger' had to be understood as 'physical hunger', 'desire to eat' as a 'general desire to eat for any reason', and 'fullness'

Table 1 Description of the four finger foods offered during the tasting session and the buffet-style snack

Ingredients	Energy density status; kcal/g	Sweet/savory status	Energy content (kcal)
Tomato and mussel brochette with vinaigrette	Low; 0.94	Savory	19.7
Ham and goat cheese brochette with pine nuts and walnuts	High; 6.91	Savory	165.8
Fruit brochette (blueberry, mango, raspberry, blackberry)	Low; 0.66	Sweet	16.5
Chocolate candy	High; 6.32	Sweet	79.0

as a 'physical feeling of fullness in the stomach'. FIZZ Sensory Software 2.47B by Biosystèmes (Couternon, France) was used for automatic data capture and to transform the results into a score from 0 to 10.

Food Choices and Energy Intake

Food choices and energy intake during the buffet-style snack were assessed, counting the number of each type of finger food eaten during the 15 min. Food was also weighed when the finger foods were not entirely eaten. Total energy intake, energy intake from each category of finger foods, and carbohydrate, lipid, and protein intake (expressed in kcal) were calculated for each subject.

Liking of the Finger Foods

At T1, the participants were asked to rate their liking of the four finger foods eaten during the tasting session on a 100-mm electronic VAS. FIZZ was used for automatic data capture and to transform the results into a score from 0 to 10.

Mindfulness State (MS)

At T1, participants were also asked to answer a 21-item questionnaire to measure their MS at the time of the tasting session. A Spanish adaptation of the State Mindfulness Scale (SMS), developed and validated by Tanay and Bernstein (2013), was used. It measures the perceived level of awareness and attention paid to their present experience during a specific period of time (i.e., the past 15 min) and context (e.g., following mindfulness meditation or another activity) on a 5-point scale (*1 = not at all* to *5 = very well*). The measure was translated and back-translated by experts on mindfulness research and a native English speaker, using structured guidelines.

Other Measurements

At T3, the participants received an email with a link to a final online survey containing the 33 questions from the validated Spanish version (Cebolla et al. 2014) of the Dutch Eating Behavior Questionnaire (DEBQ) (van Strien et al. 1986) for the assessment of restrained, emotional, and external eating behavior.

Data Analyses

All the statistical analyses were conducted using the SPSS for Windows (version 22). Due to missing data, the analyses of the DEBQ were carried out with 69 participants, and the missing values (ranging from 0 to 1.5% per item) were imputed using the Expectation-Maximization Algorithm method.

Mixed ANOVAs were carried out to assess the effects of the ME induction on hunger, fullness, and desire, with condition (mindful and control) as between-subjects factor and time (T0, T1 and T2) as within-subjects factor. Furthermore, separate ANCOVAs (controlling BMI) were used to test for differences between the two conditions on the number of finger foods eaten (by finger food item, by category of finger food, and in all) and energy intake (by category of finger food, by macronutrient, and in all) during the buffet. Next, Student's unpaired *t* tests were performed to assess the effects of the ME induction on liking scores and MS. Finally, moderation analyses were carried out to examine whether the relationships between the conditions and total energy intake or total number of finger foods eaten were moderated by eating behaviors (restrained, emotional, and external eating) and MS. To do so, we followed the procedure described by Hayes (2013) using the macro PROCESS for SPSS, version 2.16. However, as only EE and MS were significant moderators of this relationship, we carried out two moderation analyses with these two variables together (Fig. 1). Tests of significance ($p < .05$) or confidence interval (not including zero), based on the conditional effect of condition on the total number of finger foods/total energy intake when MS changes by one unit (holding EE constant) or when EE changes by one unit (holding MS constant), answered the question about whether MS and EE moderated the effect of condition on the total number of finger foods/total energy intake. The control condition was coded as "1", and the mindful condition was coded as "2" (e.g., a negative relationship between condition and total number of finger foods or total energy intake meant that participants in the control condition ate a greater total number of finger foods or had more energy intake, and those in the

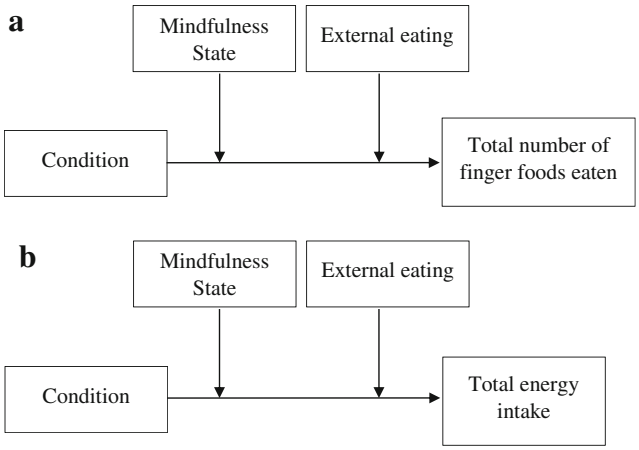

Fig. 1 Diagram of moderations of the effect of condition on total number of finger foods eaten (**a**) and total energy intake (**b**) by mindfulness state and external eating

mindful condition ate less). We used the pick-a-point approach (Bauer and Curran 2005) to examine the conditional effect of condition on total energy intake and total number of finger foods eaten at medium (the mean), low (−1 *SD*), and high (+1 *SD*) levels of both moderators.

Results

Table 2 shows the descriptive statistics for age, BMI, SMS, DEBQ, and liking of finger food scores in the two conditions: mindful vs. control.

Table 2 Descriptive statistics for age, BMI, SMS, DEBQ and liking of finger foods scores in mindful (n = 35) and control (n = 35) condition

	Control condition $M \pm SEM$	Mindful condition $M \pm SEM$
Age (years)	35.68 ± 2.02	34.86 ± 1.56
BMI (kg/m^2)	22.23 ± 0.51	23.36 ± 0.72
SMS scores	74.86 ± 2.44	80.23 ± 2.12
DEBQ scores[a]		
Emotional eating	2.63 ± 0.13	2.62 ± 0.15
External eating	3.46 ± 0.09	3.26 ± 0.10
Restrained eating	2.67 ± 0.08	2.53 ± 0.12
Liking of finger foods		
LED savory	6.74 ± 0.40	7.03 ± 0.40
HED savory	8.04 ± 0.32	7.38 ± 0.43
LED sweet	6.77 ± 0.41	7.15 ± 0.38
HED sweet	7.03 ± 0.10	7.20 ± 0.42

BMI body mass index, *SMS* State Mindfulness Scale, *DEBQ* Dutch Eating Behavior Questionnaire, *HED* high-energy-dense, *LED* low-energy-dense

[a] Due to missing values, the analyses for DEBQ were carried out with n = 34 in both groups

Subjective Appetite

Results for hunger, fullness, and desire to eat are shown in Table 3. There were main effects of time on the three measures of subjective appetite, showing higher levels of fullness at T1 (between the tasting session and the buffet-style snack) and T2 (right after the buffet-style snack) than at T0 (before the video), and lower levels of hunger and desire to eat at T1 and T2 than at T0. Furthermore, results showed higher levels of fullness and lower levels of hunger and desire to eat at T2 than at T1. Nevertheless, there were no significant interaction effects between condition and time in any variable.

Food Choices and Intake During the Buffet-Style Snack

Table 4 shows the results for food choices (number of finger foods eaten) and the resulting energy intake during the buffet-style snack, presented by each finger food item individually, by finger food category (sweet, savory, high-energy-dense (HED) and low-energy-dense (LED)), by macronutrient, and in all. Regarding the food choices by finger food item, participants in the mindful condition ate a larger number of HED savory finger foods than participants in the control condition. No significant between-group differences were found for the other finger food items.

Considering food choices by category of finger food, results reveal that participants in the mindful condition ate a lower number of HED finger foods, with no significant differences in the other categories (LED, savory, sweet). In the case of energy intake, HED and savory finger food energy intake was lower in the mindful condition than in the control condition.

Regarding macronutrient intake, energy intake from lipids and proteins was lower in the mindful condition than in the control condition. No significant between-group differences were found for energy from carbohydrates.

Finally, the total number of finger foods eaten and energy intake during the buffet-style snack were lower in the mindful condition than in the control condition.

Liking of the Finger Foods

There were no differences in liking of the four finger foods between participants in the mindful and control conditions (LED savory, $t(68) = 0.53$, $p = .600$; HED savory, $t(68) = 1.23$, $p = .224$; LED sweet, $t(68) = 0.68$, $p = .499$; HED sweet, $t(68) = 0.30$, $p = .767$) (Table 2).

Mindfulness State

Scores for mindfulness state (MS) were not significantly different between the mindful condition and the control condition, $t(68) = 1.66$, $p = .101$ (Table 2).

Table 3 Scores and ANOVAs results for subjective appetite at T0 (before the video), T1 (between the tasting session and the buffet-style snack) and T2 (right after the buffet-style snack)

	Control condition	Mindful condition	Main effect of time			Contrasts[a]	Condition x Time effect		
	M ± *SEM*	*M* ± *SEM*	*F*	p^a	η^2_p		*F*	p^a	η^2_p
Hunger									
T0	4.14 ± 0.33	4.07 ± 0.28	$F(1.80, 122.36) = 44.11$	< .001	.39	T0 > T1	$F(1.80, 122.36) = 1.52$	.224	.02
T1	2.66 ± 0.40	2.09 ± 0.30				T0 > T2			
T2	1.44 ± 0.23	1.81 ± 0.26				T1 > T2			
Fullness									
T0	4.39 ± 0.39	4.19 ± 0.32	$F(1.72, 116.88) = 69.01$	< .001	.50	T0 < T1	$F(1.72, 116.88) = 1.25$	.287	.02
T1	6.27 ± 0.38	6.70 ± 0.31				T0 < T2			
T2	7.59 ± 0.32	7.20 ± 0.35				T1 < T2			
Desire to eat									
T0	5.05 ± 0.32	4.71 ± 0.27	$F(2, 136) = 32.45$	< .001	.32	T0 > T1	$F(2, 136) = 1.52$	.223	.02
T1	3.47 ± 0.43	2.92 ± 0.39				T0 > T2			
T2	2.14 ± 0.33	2.63 ± 0.37				T1 > T2			

[a] Significant at $p < .05$

Moderation Analyses

Moderation analyses with one moderator showed that the effect of the condition on the total number of finger foods was moderated by external eating (EE), $F(1,65) = 5.03$, $p = .028$, and mindfulness state (MS), $F(1,66) = 5.00$, $p = .029$, but not by emotional eating, $F(1,65) = 1.34$, $p = .251$, or restrained eating, $F(1,65) = 0.08$, $p = .775$. Along the same lines, moderation analyses with one moderator showed that the effect of the condition on the total energy intake was moderated by EE, $F(1,65) = 8.46$, $p = .005$, and MS, $F(1,66) = 4.55$, $p = .037$, but not by emotional eating, $F(1,65) = 0.95$, $p = .332$, or restrained eating, $F(1,65) = 0.27$, $p = .602$. The following subsections show the results of the moderation by MS and EE in the effect of the "condition" on the "total number of finger foods eaten" and "total energy intake".

Table 4 Mean number of finger foods eaten and resulting energy intake during the buffet-style snack, by finger food item, by category of finger foods (sweet, savory, high-energy-dense and low-energy-dense) by macronutrient, and in total

	Number of finger foods eaten					Energy intake (kcal)				
	Control *M* ± *SEM*	Mindful *M* ± *SEM*	*F* [a]	*p*	η^2_p	Control *M* ± *SEM*	Mindful *M* ± *SEM*	*F*	*p*	η^2_p
Finger food item										
HED savory	1.66 ± 0.21	1.11 ± 0.17	$F(1, 67) = 4.33$	.041	.06	–	–	–	–	–
LED savory	1.46 ± 0.23	1.37 ± 0.28	$F(1, 67) = 0.25$	.621	.01	–	–	–	–	–
LED sweet	1.89 ± 0.34	1.40 ± 0.24	$F(1, 67) = 0.85$	.361	.01	–	–	–	–	–
HED sweet	0.69 ± 0.16	0.51 ± 0.13	$F(1, 67) = 1.82$	.182	.03	–	–	–	–	–
Category of finger food										
Sweet	2.57 ± 0.39	1.91 ± 0.24	$F(1, 67) = 1.85$	.178	.03	85.35 ± 14.34	63.78 ± 9.80	$F(1, 67) = 2.44$	.123	.04
Savory	3.11 ± 0.40	2.49 ± 0.34	$F(1, 67) = 2.08$	.154	.03	303.46 ± 37.67	211.74 ± 29.48	$F(1, 67) = 4.13$	.046	.06
HED	2.34 ± 0.26	1.63 ± 0.24	$F(1, 67) = 5.76$	.019	.08	328.93 ± 36.86	225.38 ± 32.41	$F(1, 67) = 5.53$	.022	.08
LED	3.34 ± 0.41	2.77 ± 0.39	$F(1, 67) = 0.93$	.338	.01	59.89 ± 7.28	50.17 ± 7.23	$F(1, 67) = 0.89$	.350	.01
Macronutrient										
Lipids	–	–	–	–	–	190.41 ± 21.04	135.54 ± 17.98	$F(1, 67) = 5.33$	.024	.07
Protein	–	–	–	–	–	53.77 ± 6.25	39.45 ± 4.88	$F(1, 67) = 4.03$	.049	.06
Carbohydrates	–	–	–	–	–	36.74 ± 4.95	28.10 ± 3.40	$F(1, 67) = 2.62$	.111	.04
Total	5.69 ± 0.61	4.40 ± 0.49	$F(1, 67) = 3.11$	.082	.04	388.82 ± 41.99	275.55 ± 34.31	$F(1, 67) = 5.31$	.024	.07

HED high-energy-dense, *LED* low-energy-dense

[a] All ANCOVA models were adjusted for body mass index

Table 5 Linear models of predictors of total number of finger foods eaten and total energy intake

	Total number of finger foods				Total energy intake			
	b	*SE b*	*t*	*p*	*b*	*SE b*	*t*	*p*
Constant	4.72 [4.06, 5.38]	0.33	14.24	< .001	307.12 [258.21, 356.04]	24.48	12.55	< .001
Condition (centered) (b^1)	−1.19 [−2.51. 0.14]	0.66	−1.79	.078	−92.48 [−190.34, 5.39]	48.97	−1.89	.064
MS (centered) (b^2)	−0.01 [−0.06, 0.04]	0.03	−0.38	.706	−2.51 [−5.98, 0.97]	1.74	−1.44	.154
Condition × MS (b^3)	0.11 [0.01, 0.22]	0.05	2.13	.037	7.86 [0.92, 14.80]	3.47	2.26	.027
EE (centered) (b^4)	0.51 [−1.24, 2.25]	0.87	0.58	.565	53.85 [−50.21, 157.91]	52.07	1.03	.305
Condition × EE (b^5)	−3.94 [−7.47, −0.42]	1.76	−2.24	.029	−318.53 [−527.83, −109.23]	104.74	−3.01	.003

Note. MS = Mindfulness state; EE = External eating; *b* = Regression beta coefficients with 95% level of confidence for the confidence intervals; *SE b* = standard errors of the regression beta coefficients; *b1* = Regression beta coefficient of the conditional effect of condition on total number of finger foods/total energy intake when MS and EE are zero; b^2 = Regression beta coefficient of the conditional effect of MS on total number of finger foods/total energy intake; b^3 = Regression beta coefficient of the conditional effect of condition on total number of finger foods/total energy intake when MS changes by one unit, holding EE constant; b^4 = Regression beta coefficient of the conditional effect of EE on total number of finger foods/total energy intake; b^5 = Regression beta coefficient of the conditional effect of condition on total number of finger foods/total energy intake when EE changes by one unit, holding MS constant

Moderation by MS and EE in the Effect of the Condition on the Total Number of Finger Foods Eaten

The overall model explained 19.35% of the variance in the total number of finger foods eaten, and it was marginally significant, $F(5,63) = 2.30$, $p = .055$. The condition × MS and condition × EE interactions were statistically significant, which means that MS and EE were moderators of the effect of the condition on the total number of finger foods eaten (Table 5). Both interactions accounted for 14.87% of the variance in the number of finger foods eaten. The moderation by MS accounted for 4.98% of the variance, $F(1,63) = 4.56$, $p = .037$, and the moderation by EE accounted for 10.10% of the variance, $F(1,63) = 4.99$, $p = .029$. Simple slopes tests showed that there was a significant negative relationship between condition and the number of finger foods eaten when EE was "high" and MS was "low", $b = -4.91$, 95% CI [− 8.28, − 1.55], $t = -2.92$, $p = .005$, or "medium", $b = -3.38$, 95% CI [− 6.04, − 0.72], $t = -2.54$, $p = .014$, and when EE was "medium" and MS was "low", $b = -2.72$, 95% CI [− 4.83, − 0.61], $t = -2.58$, $p = .012$. However, there was a marginally significant positive relationship between condition and the number of finger foods eaten when EE was "low" and MS was "high", $b = 2.54$, 95% CI [− 0.14, 5.21], $t = 1.90$, $p = .063$ (Fig. 2). Participants in the mindful condition ate a lower number of finger foods when they had medium levels of EE and low levels of MS, or high levels of EE and low/medium levels of MS. Nevertheless, in contrast to the control condition, the simple slopes graph shows that participants in the mindful condition showed a trend (but not statistically significant) toward eating more when they had low levels of EE and high levels of MS.

Moderation by MS and EE in the Effect of the Condition on Total Energy Intake

The overall model explained 26.90% of the variance in total energy intake, $F(5,63) = 3.60$, $p = .006$. The condition × MS and condition × EE interactions were statistically significant, indicating that the relationship between condition and total energy intake was moderated by MS and EE (Table 5). Both interactions accounted for 18.10% of the variance in the total energy intake. The moderation by MS accounted for 5.03% of the variance, $F(1,63) = 5.13$, $p = .027$, and the moderation by EE accounted for 13.31% of the variance, $F(1,63) = 9.25$, $p = .003$. Simple slopes tests showed that there was a significant negative relationship between condition and total energy intake when EE was "high" and MS was "low", $b = -377.94$, 95% CI [− 570.32, − 185.55], $t = -3.93$, $p < .001$, or "medium", $b = -269.48$, 95% CI [− 430.75, − 108.21], $t = -3.34$, $p = .001$, and when EE was "medium" and MS was "low", $b = -200.93$, 95% CI [− 336.89, − 64.98], $t = -2.95$, $p = .004$. However, there was a significant positive relationship between condition and total energy intake when EE was "low" and MS was "high", $b = 192.98$, 95% CI [14.89, 371.07], $t = 2.17$, $p = .034$ (Fig. 3). Participants in the mindful condition ate fewer finger foods when they had medium levels of EE and low levels of MS, or high levels of EE and low/medium levels of MS. Nevertheless, the mindful condition ate more when participants had low levels of EE and high levels of MS.

Discussion

The present study shows that a brief ME induction in adult women has effects on subsequent food choices and intake. We demonstrated that a significantly reduced

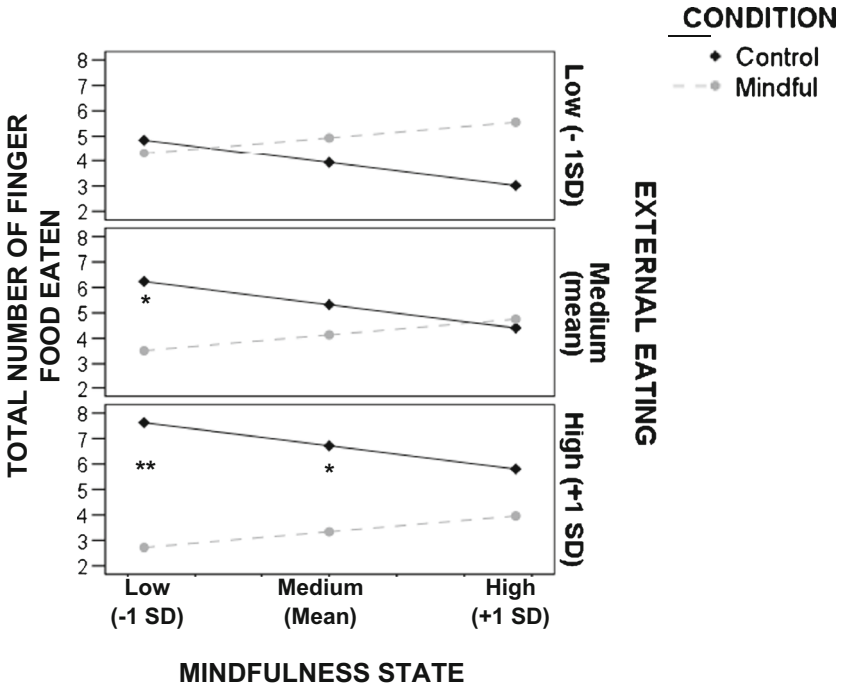

Fig. 2 Simple slopes graph of the regressions of condition on total number of finger foods eaten at three levels of EE (low, medium, and high) and MS (low, medium, and high). *Note.* "Low", "medium" and "high" levels of the moderators represent the mean and ± 1 standard deviation (SD) (External eating: 0 ± 0.56; Mindful State: 0 ± 13.80) (calculated from the entire sample, centering the mean). Significant *p* values (**p* < .05; ***p* < .01) represent the levels of the moderators in which the conditional effect of "condition" on "total number of finger foods eaten" is significant

number of high-energy-dense food items were eaten, associated with reduced total energy intake, by adults who received a brief ME induction, compared to a control group. We also demonstrated that this effect was moderated by the level of external eating (EE) and mindfulness state (MS). Overall, we showed that the mindful condition was able to reduce more, compared to the control condition, the total number of food items eaten and the total energy intake in participants who combined higher levels of EE and lower levels of MS. However, we showed that the mindful condition did not help to reduce energy intake (and even led to a greater increase in energy intake than the control condition) in participants who combined lower levels of EE and higher MS.

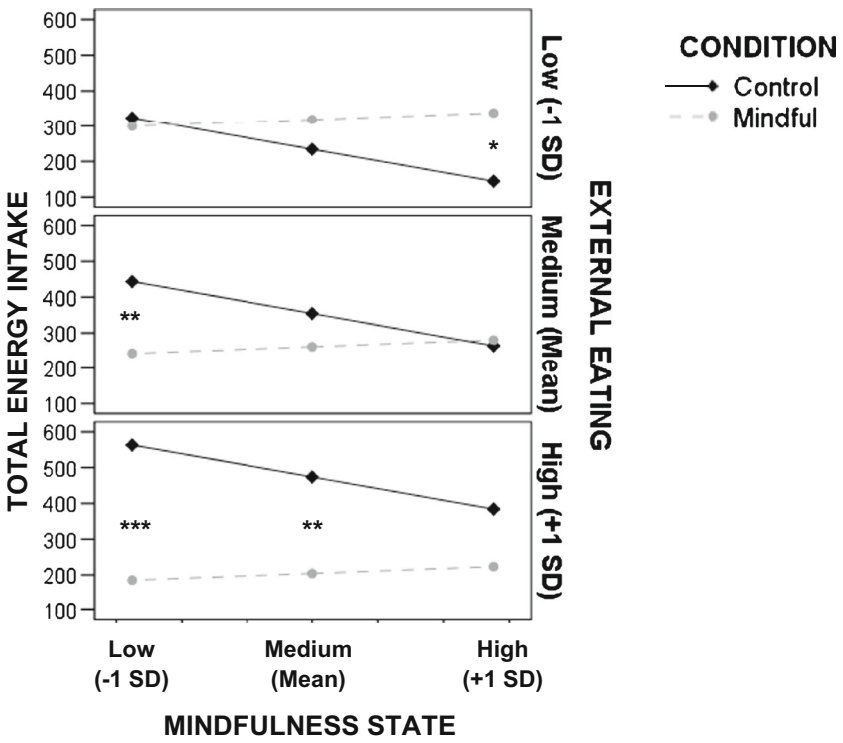

Fig. 3 Simple slopes graph of the regressions of condition on total energy intake at three levels of EE (low, medium, and high) and MS (low, medium, and high). *Note.* "Low", "medium" and "high" levels of the moderators represent the mean and ±1 standard deviation (SD) (External eating: 0 ± 0.56; Mindful State: 0 ± 13.80) (calculated from the entire sample, centering the mean). Significant *p* values (**p* < .05; ***p* < .01; ****p* < .001) represent the levels of the moderators in which the conditional effect of "condition" on "total energy intake" is significant

Our results are coherent with previous literature that demonstrated positive effects of mindfulness techniques on eating behaviors. Marchiori and Papies (2014) showed that a brief mindfulness exercise (body scan) could help to reduce the effects of hunger on unhealthy snacking. Fisher et al. (2016) also demonstrated that a brief mindful attention induction was able to decrease food intake, even when craving and hunger were experienced. Jenkins et al. (Jenkins and Tapper 2014) showed that another brief mindfulness strategy (defusion) helped individuals to resist chocolate temptation.

In the present study, as Mantzios and Wilson (2015) suggested, the mindfulness intervention we chose only focused on eating. We demonstrated that, even when focusing only on ME (without meditation), a brief intervention can have beneficial effects on eating behaviors.

Mainly, we showed that for the same level of hunger, our intervention helped to reduce choices of unhealthier food items and total energy intake. However, contrary to the findings of Papies et al. (2015), who demonstrated that, after performing mindful attention, participants decreased their consumption of unhealthy snacks and, at the same time, increased their intake of salads (healthy snack) during a meal, we did not find that a reduction in unhealthy food items was compensated by an increase in another healthier component. This difference might be explained by the fact that in the present study, the participants were not in a situation where they had to put together a meal. Instead, they were merely offered a snack between meals. A recent study highlighted that food choices and motivations were different for lunch and dinner, compared to any other eating time (Phan and Chamber 2016). Our results also agree with the findings by Beshara et al. (2013), who showed that ME might have a greater influence on serving size than daily mindfulness, suggesting that a specific ME training could be sufficient to prevent over-eating and help individuals to control the serving size of high-energy-dense foods.

In the present study, the reduction in the high-energy-dense food intake after the ME induction resulted in a significantly lower fat and protein intake, compared to controls, whereas the carbohydrate intake remained unchanged. Another study (Timmerman and Brown 2012) reported lower fat intake in an intervention group that received 6 weekly 2-h sessions, including ME meditation. However, this intervention included other components, such as small group sessions focused on reducing calorie and fat intake, and other macronutrient intakes were not measured. Our results highlight that one brief ME induction can help to decrease fat and protein intake.

In the present study, the results for food choices and total energy intake were observed without any effect on subjective hunger, fullness, or desire to eat scores. The brief ME induction did not lead to reduced hunger scores or increased fullness scores. Our results contrast with those found by Fisher et al. (2016), who reported no change in hunger and an increase in fullness from pre to post food-cue exposure following attention with a mindful attitude, whereas fullness remained the same and hunger increased in a control group.

The between-group differences in the number of food items eaten were not explained by a difference in the liking of these foods. All the participants declared before the beginning of the study that they liked all the foods that would be offered. We did not find any differences between groups in the liking of the food items actually tasted during the experiment. Hong et al. (2014) showed that ME practices were beneficial in promoting greater enjoyment of previously disliked or avoided foods. They also suggested that the effect of ME on food liking could depend on initial food liking. Our results confirm this assumption, as we did not find any impact of an ME induction on food liking for already liked food.

One of the main findings of the present study resulted from the moderation analysis of the effect of the ME induction on subsequent food choices and intakes. We showed that the efficacy of an ME induction in reducing energy intake was moderated by individuals' levels of MS and EE. The intervention was more effective in reducing the total number of food items eaten and the total energy intake in individuals who combined high EE scores and low MS. EE is characterized by eating in response to external food-related cues (i.e., the sight, smell, and taste of food) (van Strien et al. 2009), and it is associated with poor dietary intake, over-eating (Burton et al. 2007; van Strien et al. 2009), and snack consumption (van Strien et al. 2012). Externality theory posits that individuals who engage in EE overeat because of a heightened attentional bias toward external food cues (Schachter and Rodin 1974). ME could mitigate EE by teaching skills that help one to acknowledge impulses but not act on them, as in impulses to eat in reaction to the sight and smell of food (O'Reilly et al. 2014). In the present study, the participants were offered a buffet-style snack while they declared quite low levels of hunger. Therefore, even though the results might have also been due to an internal drive to eat, as in reward-based eating (Epel et al. 2014), we can hypothesize that their food choices were more driven by external food cues than by internal hunger signals. Therefore, the brief ME induction helped to reduce EE in habitual external eaters who presented the lowest MS. In a recent literature review on MBI (O'Reilly et al. 2014), four out of six studies that targeted EE reported improvements in EE frequency. Our results support this finding and suggest that a single ME induction could be effective in promoting beneficial changes in short-term eating decisions, and that individuals with high levels of EE and low MS should be targeted. We found that in participants with the opposite pattern, consisting of lower levels of EE and higher MS, the ME induction led to an increase in energy intake. We hypothesize that individuals with a low tendency to eat in reaction to external cues, such as the sight and smell of food, could be more willing to eat after a food tasting in which they were invited to

pay attention to these external cues, but only if they were aware and in the present moment. Another possible explanation would be that the ME exercise produces an increase in the appreciation for these foods in lower external eaters who score higher on MS, thus increasing consumption, whereas participants who score higher on EE might have become more aware of the inclination to overeat and consciously suppressed it.

These results show that an ME induction may be most effective in directing food choices toward healthier food items and reducing energy intake in individuals with high EE scores, which is a frequent eating style in obesity.

Study limitations include the setting for the experiments. The BCC is a well-known university in gastronomic sciences, and participating in a tasting session in this type of center is not common for the participants, which could have created expectations about the food proposed and/or led to overconsumption due to the context. In a previous study (Allirot et al. 2013), the same experimental protocol was replicated in a school of culinary art and in a hospital, and although the trends in the results were the same in both places, hunger scores and desire to eat savory foods and foods rich in energy were higher in the culinary art school. Further studies should confirm the results of the present study in natural contexts. The sample, consisting only of adult women, does not allow us to generalize our results to other populations. Thus, it remains to be seen whether the results of the present study also hold true for men. In order to keep participants from suspecting the real aim of the study, we decided to measure MS only after the induction, which could also be considered a limitation because we do not know how the induction contributed to individual changes in MS. Furthermore, the DEBQ was also measured after the experiment, with no information about possible confounding variables.

In the future, the effect of an ME induction should be assessed in other populations, such as individuals with specific weight status (e.g., obesity), diseases (e.g., diabetes), eating behaviors (e.g., emotional eaters) or ages (e.g., children). In the present study, we only assessed the short-term effects of an ME induction in a specific "between-meals" context. Further studies should explore the effects of an ME induction in a meal context using a more in-depth and long-term perspective.

The present study demonstrates that a single ME induction can help to reduce unhealthy food choices and energy intake. It demonstrates in an experimental setting the beneficial effect of a brief ME induction on subsequent food choices and energy intake, and the relationships with EE and MS. As suggested previously by various authors (Beshara et al. 2013; Fisher et al. 2016; Mantzios and Wilson 2015), our study proposes an efficient mindfulness-related eating strategy, without involving traditional meditation practices, suggesting that simple ME strategies can be used to enhance diet quality, control energy intake, and prevent overweight, even in people not ready to engage in meditation practice. Although further studies are necessary in other contexts and from a long-term perspective, the present pattern of results encourages the promotion of ME, particularly in external eaters. It also supports the recent call to incorporate ME strategies into the current arsenal of tools to promote overall healthy eating for disease prevention (Fung et al. 2016).

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Author Contributions XA designed and executed the study, assisted with the data analysis, and wrote the paper. MM analyzed the data and assisted in writing the paper. IP collaborated with the design and executed the study. RMB and EU collaborated with the design and edited the final manuscript. AC designed the study, assisted with data analysis, and wrote the paper.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflicts of interest.

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