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Can mindful eating buffer against the influence of neighbourhood fast food exposure on unhealthy food intake?

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ABSTRACT

A food-abundant environment is associated with unhealthy food intake, but not everyone is affected to the same degree. Mindful eating, which is eating with attention and awareness, has been associated with less external eating and less food cravings, and could act as a protective factor against influences from the food environment. The current study aimed to investigate whether the association between exposure to fast-food around the home and unhealthy food intake was moderated by mindful eating. The study was conducted in 1086 Dutch adults of 55 years and older of the Longitudinal Aging Study Amsterdam study. The mindful eating domains (Mindful Eating Behavior Scale) were tested as moderating variables in the linear regression models with absolute and relative density of fast-food outlets in the neighbourhood (400, 800 and 1600m) as independent variables and unhealthy food intake (snacks (g/d)) and saturated fat as a percentage of total energy intake (en%)) as dependent variable. Bootstrapping with 5000 samples using the pick-a-point approach showed that after adjustments, only two out of 48 interactions terms were statistically significant: Eating with Awareness (EwA) and Eating without Distraction (EwD) moderated the positive association between the relative density of fast-food outlets and saturated fat (en%) respectively in a buffer of 800m (interaction EwA: B = −0.84, 95% CI [-1.46; −0.22]) and in a buffer of 1600m (interaction EwD: B = −0.82, 95% CI [-1.61; −0.04]). The results of the current study indicate that mindful eating cannot buffer against the influence of the fast-food abundant environment on unhealthy food intake. Future research is needed to confirm these findings, for example in younger populations.

1. Introduction

A sub-optimal diet is an important risk factor for disability-adjusted life years and deaths worldwide (World Health Organization, 2022). In the Netherlands, unhealthy food intake contributes an estimated 8.1% to the burden of disease, and leads to 6 billion euro healthcare costs per year (Hilderink and Verschuuren, 2018). Food intake results from a complex interplay of internal, e.g., psychological, and external, e.g., environmental factors (Vogel et al., 2019; Brug, 2008). Environmental influences, such as the current food-abundant environment in which unhealthy choices are readily available (Monteiro et al., 2013), make it difficult to achieve and maintain the goal of eating healthily (Hill et al., 2003; Penney et al., 2017). However, evidence for a relation between exposure to the food-abundant environment and unhealthy food intake is inconsistent (Caspi et al., 2012). One of the potential explanations for this inconsistency might be that not everyone is affected to the same degree by exposure to the food-abundant environment. Internal factors might play a role in this, such that certain protective psychological resources make some people better able to resist temptations from the food-abundant environment. Research indeed suggests that certain people might be less susceptible to the obesogenic environment than others, such as adolescents with a higher competence in employing self-regulation strategies (de Vet et al., 2013; Luszczynska et al., 2013), adults with a higher combined score on perceived control over life,

Abbreviations: HSc, Eating in response to Hunger and Satiety Cues; EwA, Eating with Awareness; EwD, Eating without Distraction; FE, Focused Eating; FFQ, Food frequency questionnaire; LASA, Longitudinal Aging Study Amsterdam; MEBS, Mindful Eating Behavior Scale.

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self-efficacy for healthy eating, healthy eating outcome expectancies, food involvement (Vogel et al., 2019), adults with a better inhibitory control to high-calorie foods (de Vries et al., 2022), and adults with a lower appetitive drive to consume highly palatable food (Schüz et al., 2015).

Another potential protective factor could be mindful eating. Mindful eating is a domain-specific type of mindfulness, for which there is currently no universally accepted definition (Román and Urbán, 2019; Tapper, 2022). Mindful eating, like generic mindfulness, appears to be multifaceted, but there is no consensus on the key principles to include when defining the term mindful eating (Mantzios, 2021). There is a variety of definitions for *generic* mindfulness, some containing only an attention element (Brown and Ryan, 2003, 2004; Mikulas, 2011; Grabovac et al., 2011), others also incorporating a second element, namely acceptance (Bishop et al., 2004; Baer et al., 2006; Kabat-Zinn and Hanh, 2009). Attention is the self-regulation of attention in the present moment while paying attention non-judgementally can be defined as acceptance. Some studies suggest that paying attention is needed first to be able to pay attention nonjudgmentally (Brown et al., 2007; Chiesa, 2013). In this study, mindful eating is defined as 'eating with attention and awareness' and thus only incorporates the attention element (see Winkens, van Strien (Winkens et al., 2018)). In this definition, mindful eating consists of different domains such as Focused Eating, Eating in response to Hunger and Satiety Cues, Eating with Awareness, and Eating without Distraction (Brown et al., 2007).

There are some explanations for the potential protective effect of mindful eating to unhealthy food environments. In a previous study, higher mindful eating was associated with less external eating, which is eating in response to food cues from the environment (Winkens et al., 2019). Having an external eating style is among others associated with a higher level of food cravings (Burton et al., 2007). Higher craving is also associated with a stronger attention and approach bias towards food (Brockmeyer et al., 2015). When mindfulness exercises have been repeatedly practiced over a longer period of time, mindfulness might reduce cravings to food (Tapper, 2018). Older adults low in mindfulness continued to be pre-occupied with the elaboration of food cues after a brief period of food restriction, even after cue exposure had ended (Paolini et al., 2012). Higher mindful eating might thus potentially lead to less cue reactivity or a faster 'recovery' from these cues, reduced food cravings and less external eating.

Research into the role of mindful eating in the associations between the food-abundant environment and food intake is needed. Therefore, the current study aims to investigate whether mindful eating could act as a protective factor against living in environments with a high exposure to fast-food. This leads to the following research question: Does mindful eating moderate associations between absolute and relative density of fast-food outlets in the neighbourhood (400, 800 and 1600m) and unhealthy food intake (snacks (g/d) and percentage saturated fat of total energy intake (en%)) in adults aged 55 years and older? The hypothesis is that the association between higher density of fast-food outlets and unhealthy food intake is stronger in people with lower levels of mindful eating.

2. Methods

2.1. Participants and procedure

Data were collected within the Longitudinal Aging Study Amsterdam (LASA), an ongoing cohort study in a representative sample of Dutch older adults aged 55 years and over. LASA comprises three cohorts: the first cohort (aged 55–85 years at baseline) was recruited at LASA's start in 1992–1993, the second one (55–65 years) in 2002–2003, and the third one (55–65 years) in 2012–2013. Participants live in three geographic regions in the Netherlands: Amsterdam, Zwolle, Oss, and the suburbs of these regions. The regions cover the predominantly protestant northeast, the largely catholic south and the more secularized western part of the Netherlands, and include both urbanized and rural areas (Huisman et al., 2011; Hoogendijk et al., 2016, 2020). Ethical approval for the LASA study was given by the Medical Ethics Committee of the VU University Medical Center Amsterdam and all participants provided written informed consent.

The current study is a cross-sectional study. Participants were respondents of the LASA study who filled out the questionnaire of the ancillary 'LASA Nutrition and Food-related Behaviour study' that was conducted between the fall of 2014 and the spring of 2015 (for details, see Winkens, van Strien (Winkens et al., 2018)). Mindful eating and food intake were measured in the this ancillary study. Locations of fast-food outlets were derived from field audit data from 2014 and fast-food outlet density was calculated in a Eucledian buffer around the participant's residential address. Confounding variables were measured in the 3-yearly measurement waves of LASA: sex, age and educational level at the baseline measurements; smoking status, physical activity level, alcohol consumption and level of urbanization either in 2011–2012 (cohort 1 and 2) or 2012–2013 (cohort 3). For BMI, the mean of the measurements in 2011–2012/2012–2013 and 2015–2016 was calculated.

Respondents with one or more missing values on one of the used variables were excluded from the corresponding analyses, as imputation is not possible when running analyses with the Process macro for moderation analyses (Hayes, 2013). Respondents with eleven or more missing values on the 238-item Food Frequency Questionnaire were also excluded, as were respondents with implausible high energy intakes (>4000 kcal for men and >3500 kcal for women) (Willett, 1998) [2] Respondents who moved between the measurement of the covariates and measurement of mindful eating and food intake were excluded as well, as density of fast-food outlets in their surroundings changed during this time period.

2.2. Measures

2.2.1. Density of fast-food outlets

Data on the retail food environment was obtained from the commercial Dutch company Locatus, which collects information on different types of retail outlets by performing regular field audits. Locatus collects information on type of retailer and x and y coordinates of food retailer locations and categorises branches of retailers. In this study, the data dating from 2014 were used. A validation study by Canalia, Pinho (Canalia et al., 2020) showed that the validity of location of food retailers, classification of food retailers and location and classification combined was "good" to "excellent" compared to field audits in selected areas across the Netherlands in 2019.

In this study, the retail information from Locatus was used to categorize fast-food outlets. Three retail categories typically selling fast-food were categorized as fast-food outlet: 1) fast-food outlets (e.g. McDonald's, local "snackbar"), 2) delivery/take-away outlets (e.g. Chinese, pizza); 3) grillroom/kebab outlets. These three retail categories included chain and non-chain outlets selling quickly prepared and served, mainly energy-dense, foods for in-store consumption and/or takeaway and/or delivery.

The density of fast-food outlets was calculated in Euclidean buffers of 400, 800 and 1600m around the residential address (representing walks of approximately 5, 10 and 20 min). Both the absolute (count) and the relative density (count/total outlets) of fast-food outlets was used. Some research indicates that the combination of food environment features

[2] A sensitivity analysis including participants with extremely high energy intakes changed our results (8 significant interactions instead of 2 significant interactions; see Appendix). Since these extreme energy intake values are probably caused by the measuring instrument and do not reflect actual extremely high energy intakes (Shahar et al., 2010), we do not regard these results as leading.

(relative density) explains if people consume fast-food (Polsky et al., 2016; Walker et al., 2020), whereas the study of Pinho, Mackenbach (Pinho et al., 2019) found that only an absolute density measure was related to dietary intake in different European countries. It therefore seems useful to explore both the absolute density of fast-food outlets and the relative proportion of fast-food outlets of the totality of other outlets.

2.2.2. Food intake

Food intake was assessed using a 238-item semi-quantitative food frequency questionnaire (FFQ) with a reference period of 4 weeks, that was developed for the HEalthy LIfe in an Urban Setting study (HELIUS) (Beukers et al., 2015). To calculate nutrient intake, all food items were linked to a nutrient database that was based on the Dutch Food Composition Database (NEVO-tabel 2011, 2011). Unhealthy food intake in the current study is defined in two different ways: 1) the intake of unhealthy snacks (g/d, sum of sweet snacks, savoury cold and warm snacks), including fast-food meals (French fries, pizza, hamburger) as we could not differentiate between fast food eaten for dinner or in between meals; 2) saturated fat as a percentage of total energy intake (en%). The relative validity of this HELIUS FFQ to assess dietary intake in Dutch older adults was acceptable to good (Visser et al., 2020). The relative validity of the FFQ for the intake of macronutrients (e.g. fat) was comparable to the relative validity of other FFQs in younger adults. The correlation coefficients for the FFQ and three 24-h dietary recalls were 0.32 for the intake of energy intake, 0.26 for total fat, 0.43 for saturated fatty acids, 0.34 for fast-food/snacks, 0.42 for sugar/sweets and 0.38 for cakes/cookies. The agreement between the FFQ and the three 24-h dietary recalls, based on the quintile distributions of the intakes of energy, nutrients, and food groups was high for energy intake and sugar/sweets (respectively 2% and 1% in extreme quintile) and moderate for total fat, fast-food, and cakes/cookies (respectively 7%, 7% and 5% in extreme quintile) (Visser et al., 2020).

2.2.3. Mindful eating domains

The Mindful Eating Behavior Scale (MEBS) (Winkens et al., 2018) was used to measure the level of four different domains of mindful eating: Focused Eating (5 items, e.g. 'I notice how my food looks'); Eating in response to Hunger and Satiety Cues (5 items, e.g. 'I trust my body to tell me when to eat'); Eating with Awareness (3 items, e.g. 'I eat something without being really aware of it', reversed item); and Eating without Distraction (4 items, e.g. 'I multi-task when I am eating', reversed item). Answer options ranged from 1 'never' to 5 'very often'. Scores per domain were summed so that higher scores indicate a higher level of mindful eating. The MEBS showed good convergent validity in a sample of Dutch adults aged 55 years and older (Winkens et al., 2018). As inter-factor correlations between the four domains were low, a total score combining the four domains is not calculated. Cronbach's alpha of the mindful eating domains were 0.84 for Focused Eating, 0.89 for Eating in response to Hunger and Satiety Cues, 0.81 for Eating with Awareness, and 0.70 for Eating without Distraction.

2.2.4. Covariates

Covariates in different models were sex, age, educational level, smoking status, physical activity level and alcohol consumption. Analyses were additionally adjusted for BMI and level of urbanization.

Sex and age were derived from the municipal registries.

Educational level was self-reported and categorized into low (none, elementary school), medium (secondary education, lower and intermediate vocational training) and high (higher vocational training, college and university education).

Smoking status (never-former-current) was self-reported.

Physical activity was measured using the validated LASA Physical Activity Questionnaire (LAPAQ) (Stel et al., 2004). Frequency and duration of walking outdoors, bicycling, light and heavy household activities and sports in the past two weeks was asked. Total time in minutes per day spent on these activities was calculated.

Alcohol consumption was assessed by asking respondents about the number of days per week they drank alcohol and the number of alcoholic drinks on these days (Central Bureau of Statistics, 1989). The number of alcoholic consumptions per week was calculated.

Body mass index (BMI) in kg/m^2 was calculated by dividing measured weight by measured height in squared meters. Weight was measured to the nearest 0.1 kg using a calibrated bathroom scale (Seca, model 100, Lameris, Utrecht, The Netherlands). Corrections have been made to adjust the measured body weight for clothing, shoes or a corset (minus 1 kg for one of those elements and minus 2 kg for more than one) when people did not wear underclothing only. Height was measured to the nearest 0.001m using a stadiometer. Corrections have been made to adjust the measured height for shoes (minus 1 cm) when people did not take their shoes off.

Level of urbanization was operationalised as the mean number of addresses per km^2 within a circle with a radius of 1 km (Dulk et al., 1992). Data are provided by Statistics Netherlands and are defined in five categories: 1 'not urbanized (<500)', 2 'little (500–1000)', 3 'somewhat (1000–1500)', 4 'highly (1500–2500)' and 5 'very highly (>2500)'. The postal code (with the alphanumeric extension) served as the variable to match the data with the respondents.

2.3. Statistical analysis

All analyses were conducted using SPSS 29. Sample characteristics were described as means and standard deviations or percentages. Spearman correlation coefficients were calculated between the mindful eating domains, food intake and the absolute and relative density of fast-food outlets in the neighbourhood.

Plotting standardized residuals against standardized predicted values showed no indication of non-linearity or heteroscedasticity. There was also no indication of multicollinearity, since variance inflation factors among predictor variables were all below 10 and tolerance values above 0.1.

Associations between the amount of fast-food outlets in the environment (400, 800 and 1600 m buffer sizes) and both outcomes (grams of unhealthy snacks and energy percentage saturated fat) were first tested using multiple linear regression. These analyses were adjusted for sex, age, educational level, smoking status, physical activity level, alcohol consumption and level of urbanization. Unstandardized beta's (B) and 95% confidence intervals (CI) were reported. Results were considered statistically significant when the 95% CI did not contain zero.

Moderation of the four mindful eating domains separately in the associations between the amount of fast-food outlets in the environment (400, 800 and 1600 m buffer sizes) and both outcomes (grams of unhealthy snacks and energy percentage saturated fat) were tested using the bootstrap moderation method as described by Hayes (2013). See Fig. 1 for the conceptual model. This method calculates the conditional effect of density of fast-food outlets on unhealthy food intake at different values (−1 SD, mean, +1 SD) of the moderator (mindful eating). This

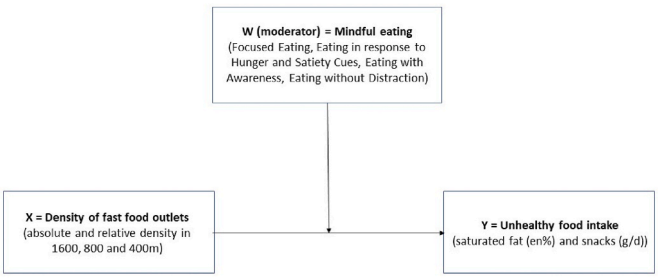

Fig. 1. Conceptual model. Conceptual model of the moderation analyses in which the mindful eating domains are tested as moderators in the associations between density of fast-food outlets and food intake.

approach is called the pick-a-point approach (Bauer and Curran, 2005) and is the most common method used for probing interactions in a linear model in the behavioral sciences (Hayes, 2012) as it is informative and easy to use (Dulk et al., 1992). The analyses were run using SPSS with the process macro of Hayes (2013) and were conducted separately for the absolute and the relative density of fast-food outlets. Bootstrapping with 5000 samples was used and unstandardized beta's were reported. Results were considered statistically significant if the upper and lower bound of the percentile bootstrap 95% CI for the interaction effect did not contain zero.

To test whether interaction effects are independent from demographic and lifestyle variables, analyses were adjusted for sex, age, educational level, smoking status, and physical activity level (model 2), and additionally for alcohol consumption and level of urbanization (model 3; main model). It was also tested if any of the interaction effects changed when the analyses were additionally adjusted for BMI.

3. Results

3.1. Analytical sample

In the ancillary 'LASA Nutrition and Food-related Behaviour study' 1439 respondents participated, of which 1314 filled out the questionnaire themselves instead of by family members. People were excluded who had one or more missing values on the MEBS ($n = 69$), as well as people with extreme high values for energy intake based on sex-specific cut-offs ($n = 18$) or people with >10 missing values on the FFQ ($n = 4$). People with missing values on any of the confounding variables ($n = 100$) and data on food outlets ($n = 2$) were excluded. Exclusion of people who moved between the measurement of the food outlets in the environment and the ancillary study ($n = 35$) resulted in an analytical sample of 1086 people. Comparison of included ($n = 1086$) and excluded people ($n = 353$) showed that excluded people were older ($p < 0.001$) and lower educated ($p < 0.001$). Table 1 shows the characteristics of the included sample. The age of the sample ranged from 56 to 97 years, with a mean age of 66 years (SD = 7.7) and 53% was female. The median number of fast-food outlets within 1600m was 5 (IQR: 2–18). The median ratio of fast-food outlets to all outlets within 1600m was 0.18 (IQR: 0.12–0.22). Mean intake of saturated fat (en%) was 12.6 (SD = 3.1) and mean intake of snacks (g/d) was 84.7 (SD = 49.3).

3.2. Correlations

Pearson correlations between variables are shown in Table 2. The independent variables (density of fast-food outlets) were not correlated with the dependent variables (unhealthy food intake). The absolute density of fast-food outlets was significantly correlated with the mindful eating domain Focused Eating (0.12 for all three buffer zones of 1600, 800 and 400 m). The relative density of fast-food outlets was significantly correlated with Eating in response to Hunger and Satiety Cues (1600m = 0.08; 800m = 0.07; 400m = 0.09). The dependent variable saturated fat (en%) was not correlated with any of the other variables. The dependent variable snacks (g/d) was correlated with EwA (−0.14) and with EwD (−0.12) but not with the other two mindful eating domains.

3.3. Linear regression analyses

Table 3 shows the results of the adjusted multiple linear regression analyses between density of fast-food outlets and saturated fat intake (en %) and snacks intake (g/d). Only one significant association was found: The absolute density of fast-food outlets in a buffer of 1600 m was significantly associated with the intake of snacks (g/d) (B = 0.008, 95% CI [0.007; 0.151].

Table 1
Characteristics of the study sample of Dutch people aged 55 years and older (n = 1086).

Age in years, mean [SD]	66.5 [7.7]
Sex, % (*n*) female	53.0 (576)
Education, % (*n*)	
Low	11.1 (121)
Medium	57.6 (625)
High	31.3 (340)
Physical activity in min/d, mean [SD]	158.7 [107.2]
Alcohol use in glasses/week, mean [SD]	9.9 [10.4]
Smoking, % (*n*)	
Never	28.8 (313)
Former	59.8 (649)
Current	11.4 (124)
Body mass index in kg/m^2, mean [SD]	27.0 [4.2]
Density of fast-food outlets, median (IQR)	
Absolute: number of fast-food outlets	
1600m	5 (2-18)
800m	2 (1-5)
400m	0 (0–2)
Relative: Ratio of fast-food outlets to all outlets	
1600m	0.18 (0.12–0.22)
800m	0.16 [0.07–0.23)
400m	0 (0–0.2)
Mindful eating (MEBS score), mean [SD]	
Focused Eating	20.1 [3.2]
Eating in response to Hunger and Satiety Cues	15.5 [5.2]
Eating with Awareness	13.0 [2.0]
Eating without Distraction	15.4 [2.7]
Saturated fat (% of total energy intake (en%)), mean [SD]	12.6 [3.1]
Snacks (g/d), mean [SD]	84.7 [49.3]
Level of urbanization in number of addresses per km^2, % (*n*)	
Not (<500)	13.3 (144)
Low (500–1000)	28.7 (312)
Moderate (1000–1500)	8.0 (87)
High (1500–2500)	30.6 (332)
Very high (≥2500)	19.4 (211)

Notes: SD = standard deviation; MEBS = Mindful Eating Behavior Scale.

3.4. Moderation analyses

Table 4a (saturated fat intake (en%)) and 4b (snacks intake (g/d)) show the results of the pick-a-point moderation analyses. When looking at the main model (model 3), only two significant interactions were found: 1) Eating with Awareness (EwA) moderated the association between the relative density of fast-food outlets in a buffer of 800 m and saturated fat (en%) (interaction: B = −0.84, 95% CI [−1.46; −0.22]) and 2) Eating without Distraction (EwD) moderated the association between the relative density of fast-food outlets in a buffer of 1600 m and saturated fat (en%) (interaction: B = −0.82, 95% CI [−1.61; −0.04]). The results did not change when BMI was added to model 3.

4. Discussion

In the current study, we explored whether mindful eating moderates associations between absolute and relative density of fast-food outlets in the neighbourhood (400, 800 and 1600m) and unhealthy food intake (snacks (g/d) and % saturated fat of total energy intake (en%)) in adults aged 55 years and older. The study shows no evidence for the hypothesis that the association between higher density of fast-food outlets and unhealthy food intake is stronger in people with lower levels of mindful eating. Of the 48 different interactions that we tested between different buffer zones of the density of fast-food outlets and the mindful eating domains on the outcomes 'saturated fat (en%)' and 'snacks (g/d)', only two interaction effects were significant. These interactions show that people with higher scores on EwA and EwD consume a lower percentage saturated fat (en%) while living in areas with a high relative density, while people with lower levels of EwA and EwD consume a higher percentage saturated fat (en%) when living in these areas. This means that higher Eating with Awareness (EwA) might protect from relative

Table 2
Correlations between variables in Dutch people aged 55 years and older (n = 1086).

Variables	Focused Eating	Hunger and Satiety Cues	Eating with Awareness	Eating without Distraction	Saturated fat (en %)	Snacks (g/d)
Saturated fat (en%)	−0.05	0.00	−0.41	−0.01	–	–
Snacks (g/d)	−0.03	0.03	−0.14**	−0.12**	0.22**	–
Absolute density fast-food outlets 1600m	0.12**	0.06*	0.03	−0.05	−0.04	0.05
Absolute density fast-food outlets 800m	0.12**	0.05	0.05	−0.05	−0.02	0.04
Absolute density fast-food outlets 400m	0.12**	0.05	0.05	−0.05	0.01	0.02
Relative density fast-food outlets 1600m	0.00	0.08*	0.01	−0.04	0.01	0.02
Relative density fast-food outlets 800m	0.04	0.07*	0.03	−0.001	−0.02	−0.02
Relative density fast-food outlets 400m	0.05	0.09**	0.06	−0.002	0.02	0.02

*$P < 0.05$.
**$P < 0.01$.
Correlations are shown between the independent variables (food exposure: absolute and relative density of fast-food outlets), dependent variables (food intake: saturated fat (en%) and snacks (g/d)) and moderating variables (mindful eating domains: Focused Eating, Eating in response to Hunger and Satiety Cues, Eating with Awareness and Eating without Distraction) in the study sample of Dutch people aged 55 years and older from the Longitudinal Aging Study Amsterdam (n = 1086).

Table 3
Adjusted linear regression analyses of the associations between density of fast-food outlets with the dependent variables saturated fat (en%) and snacks (g/d) (n = 1086).

	Saturated fat (en%)		Snacks (g/d)	95% CI
	B	95% CI	B	
Absolute density of fast-food outlets				
1600m	−0.004	−0.009; 0.000	**0.008**	**0.007; 0.151**
800m	−0.009	−0.023; 0.005	0.20	−0.025; 0.424
400m	−0.005	−0.051; 0.042	0.369	−0.374; 1.11
Relative density of fast-food outlets compared to all outlets				
1600m	−1.211	−3.274; 0.852	7.633	−25.277; 40.544
800m	−1.171	−2.523; 0.181	−7.604	−29.187; 13.979
400m	−0.202	−1.186; 0.782	4.170	−11.521; 19.860

Note: Bold values indicate statistically significant coefficients.
Associations are shown between the independent variable absolute and relative density of fast-food outlets in buffer zones of 1600, 800 and 400m and the dependent variables saturated fat (en%) and snacks (g/d) in a sample of participants aged 55 years and older from the Longitudinal Aging Study Amsterdam (n = 1086). Analyses were adjusted for sex, age, educational level, smoking status, physical activity level, alcohol consumption and level of urbanization.

exposure to fast-food outlets in a buffer of 800m and higher Eating without Distraction (EwD) from relative exposure in a buffer of 1600m. We consider these interactions however to be an incidental finding, but more research is needed to confirm this.

Mindful eating did not buffer against the influence of the food abundant environment on unhealthy food intake in the current study. Previous studies suggest that certain people might be less susceptible to the obesogenic environment than others, e.g. adolescents with a higher competence in employing self-regulation strategies or self-regulation strategies (Caspi et al., 2012). In the current study, mindful eating was not a factor that can explain these individual differences. A recent review on mindful eating indicates that the field is not yet in a position to conclude that specific mindful eating strategies do or do not influence eating, but that there is some evidence that certain strategies, such as attention towards the sensory properties of food may be more promising than others (Schüz et al., 2015). In this study however, we did not find evidence that any of the four mindful eating domains influence the association between density of fast-food outlets and unhealthy food intake.

An explanation for the null-finding in the current study could be the age of the sample, as older adults might have more traditional dietary patterns and habits which do not include eating unhealthy food that is available at fast-food outlets (Adams et al., 2015; Janssen et al., 2018). Although it does not seem the case that older adults are exposed to fast-food outlets less often than younger people, as the density of fast-food outlets in the current study was similar to other age samples in the Netherlands (Van Rongen et al., 2020; Van Erpecum et al., 2022), it might be that they go outside less often and thus experience less temptations from these fast-food outlets. In contrast, there are also indications that older adults are more dependent on the availability of shops in their environment compared to younger adults (Hobbs et al., 2019). Higher mindful eating was previously found to be related to lower levels of external eating in the same population (Winkens et al., 2019), and also to lower cravings towards food in the general population (Tapper, 2018) and to less food cue reactivity in older adults (Paolini et al., 2012). It could be that although mindful eating might be a determinant of reactivity to food cues, this does not directly translate into effects on unhealthy food intake.

Another explanation for this null-finding might be that the density of fast-food outlets was not related to unhealthy food intake in this sample. The linear regression analyses show that only the absolute density of fast-food outlets in a buffer of 1600 m was significantly associated with intake of snacks (g/d). A recent study also showed that a high proportion of fast-food restaurants around the home of residence was not associated with diet quality or overweight and obesity in a large Dutch cohort of older adults (Harbers et al., 2021). Potential explanations for these null-findings could be due to the more indirect measures of fast-food intake, i.e. saturated fat (en%) and snacks (g/d) in the current study. As saturated fat (en%) was found to be significantly different between people that consumed fast-food and people that did not on a given day (Paeratakul et al., 2003), we choose this variable as an indicator of fast-food consumption. Since fast-food outlets in the Netherlands typically sell not only fast-food, but also candy, ice cream, milkshakes etc., we also included a variable on snack intake. However, these variables may not be specific enough to measure consumption at fast-food outlets to find significant results. A study in Dutch respondents who measured fast-food consumption more directly also showed no direct association with exposure to residential fast-food outlets (Van Rongen et al., 2020). Surprisingly, this study found that more fast-food outlets in the neighbourhood led to people being more likely to perceive fast-food consumption as more common and appropriate and these stronger neighbourhood social norms were associated with higher fast-food consumption. Future research may examine the role of social norms instead of relative and absolute density of fast-food outlets.

One strength of this study is that the we used a nationally representative sample obtained from registries of 11 municipalities across 3 culturally distinct regions in the Netherlands. This leads to variation in absolute and relative exposure to fast-food outlets. Another strength is that we made use of both a mindful eating questionnaire and a FFQ that were validated in this specific sample (Brown et al., 2007; Pinho et al., 2019). The robustness of our results was tested by using different buffer sizes. One limitation is that density of fast-food outlets, mindful eating

Table 4a
Interaction effects from moderation analyses with the dependent variable saturated fat (en%) (n = 1086).

		Model 1		Model 2		Model 3	
		B of the interaction effect	95% bootstrap CI	B of the interaction effect	95% bootstrap CI	B of the interaction effect	95% bootstrap CI
Absolute density of fast-food outlets	**Mindful eating domains**						
1600m	FE	−0.001	−0.002; 0.001	−0.001	−0.002; 0.001	−0.00	−0.002; 0.001
	HSC	0.000	−0.001; 0.001	0.000	−0.001; 0.001	0.000	−0.001; 0.001
	EWA	−0.001	−0.003; 0.001	−0.001	−0.003; 0.001	−0.06	−0.16; 0.04
	EWD	0.001	−0.001; 0.02	0.001	−0.001; 0.002	0.001	−0.001; 0.002
800m	FE	−0.002	−0.01; 0.003	−0.002	−0.01; 0.003	−0.001	−0.01; 0.003
	HSC	0.000	−0.002; 0.003	0.003	−0.003; 0.003	0.000	−0.003; 0.003
	EWA	−0.002	−0.01; 0.004	−0.003	−0.01; 0.004	−0.003	−0.01; 0.004
	EWD	0.001	−0.004; 0.006	0.001	−0.004; 0.01	0.001	−0.004; 0.01
400m	FE	−0.001	−0.002; 0.001	−0.001	−0.03; 0.01	−0.01	−0.02; 0.01
	HSC	0.000	−0.01; 0.01	0.001	−0.01; 0.01	0.000	−0.01; 0.01
	EWA	−0.01	−0.04; 0.01	−0.01	−0.04; 0.01	−0.01	−0.04; 0.01
	EWD	0.003	−0.01; 0.02	0.003	−0.01; 0.02	0.000	−0.02; 0.02
Relative density of fast-food outlets compared to all outlets	**Mindful eating domains**						
1600m	FE	**0.59**	**0.03; 1.16**	0.53	−0.04; 1.09	0.49	−0.07; 1.05
	HSC	0.04	−0.35; 0.42	0.06	−0.32; 0.44	0.09	−0.28; 0.47
	EWA	−0.88	−1.86; 0.09	−0.86	−1.82; 0.10	−0.89	−1.85; 0.06
	EWD	−0.71	−1.51; 0.09	−0.73	−1.52; 0.06	**−0.82**	**−1.61; -0.04**
800m	FE	0.01	−0.41; 0.42	−0.02	−0.43; 0.39	−0.03	−0.44; 0.38
	HSC	0.11	−0.15; 0.37	0.12	−0.14; 0.38	0.12	−0.14; 0.37
	EWA	**−0.84**	**−1.46; -0.22**	**−0.88**	**−1.49; -0.27**	**−0.95**	**−1.56; -0.35**
	EWD	−0.28	−0.76; 0.21	−0.25	−0.73; 0.24	−0.24	−0.72; 0.24
400m	FE	0.11	−0.20; 0.41	0.08	−0.22; 0.38	0.05	−0.25; 0.35
	HSC	0.07	−0.13; 0.27	0.10	−0.10; 0.29	0.10	−0.09; 0.30
	EWA	−0.21	−0.7; 0.27	−0.25	−0.73; 0.23	−0.23	−0.71; 0.24
	EWD	0.24	−0.15; 0.6	−0.07	−0.15; 0.01	0.24	−0.13; 0.61

Note: FE= Focused Eating; HSc = Eating in response to Hunger and Satiety Cues; EwA = Eating with Awareness; EwD = Eating without Distraction.
Bold values indicate statistically significant coefficients.
Model 1 (raw model) is not adjusted. Model 2 is adjusted for sex, age, educational level, smoking status, and physical activity level. Model 3 (main model) is additionally adjusted for alcohol consumption and level of urbanization.
Interaction effects are shown from pick-a-point moderation analyses between the independent variable absolute and relative density of fast-food outlets in buffer zones of 1600, 800 and 400m and the moderator mindful eating (Focused Eating, Eating in response to Hunger and Satiety Cues, Eating with Awareness, Eating without Distraction) on the dependent variable saturated fat (en%) in a sample of participants aged 55 years and older from the Longitudinal Aging Study Amsterdam (n = 1086).

and food intake were measured at the same time point, which makes it impossible to draw conclusions about the temporality of the association. In this study, we focused on fast-food outlets in circular buffers around the home, but did not take into account the wider environment or movement patterns outside these circular buffers. However, previous studies show that activity patterns of older adults are more centered around the home compared to younger populations (Hobbs et al., 2019). Another limitation is the relative small sample size of 1086 respondents. Since effects of fast-food outlet exposure on food intake are assumed to be small, very large-scale data may be needed to detect such effects.

In conclusion, mindful eating does not seem to buffer against the influence of neighbourhood fast-food exposure on unhealthy food intake. Density of fast-food outlets does also not seem directly related to unhealthy food intake in this sample of Dutch adults of 55 years and older. Future research could investigate the moderating effect of mindful eating on the association between density of fast-food outlets and unhealthy food intake in younger populations, as our results might not be generalizable to younger age samples.

Ethics approval and consent to participate

Ethical approval for the LASA study was given by the Medical Ethics Committee of the VU University Medical Center Amsterdam and all participants provided written informed consent.

Availability of data and material

The dataset analysed during the current study is not publicly available due to study participant privacy considerations. However, data access can be requested from the Longitudinal Aging Study Amsterdam via the respective data access procedure in place.

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Table 4b
Interaction effects from moderation analyses with the dependent variable snacks (g/d) (n = 1086).

		Model 1		Model 2		Model 3	
		B of the interaction effect	95% bootstrap CI	B of the interaction effect	95% bootstrap CI	B of the interaction effect	95% bootstrap CI
Absolute density of fast-food outlets	**Mindful eating domains**						
1600m	FE	−0.01	−0.04; 0.01	−0.01	−0.03; 0.01	−0.01	−0.03; 0.01
	HSC	−0.01	−0.02; 0.006	−0.01	−0.02; 0.01	−0.01	−0.02; 0.01
	EWA	0.001	−0.03; 0.03	0.01	−0.02; 0.04	0.01	−0.03; 0.04
	EWD	0.02	−0.01; 0.04	0.02	−0.01; 0.04	0.01	−0.007; 0.04
800m	FE	−0.03	−0.11; 0.04	−0.03	−0.10; 0.05	−0.03	−0.10; 0.04
	HSC	−0.02	−0.06; 0.03	−0.02	−0.06; 0.03	−0.02	−0.06; 0.03
	EWA	−0.03	−0.14; 0.07	−0.02	−0.12; 0.08	−0.02	−0.12; 0.08
	EWD	0.06	−0.01; 0.14	0.06	−0.01; 0.13	0.06	−0.01; 0.13
400m	FE	−0.13	−0.39; 0.14	−0.12	−0.38; 0.14	−0.12	−0.38; 0.14
	HSC	−0.08	−0.23; 0.07	−0.07	−0.22; 0.07	−0.07	−0.22; 0.07
	EWA	−0.10	−0.46; 0.26	−0.08	−0.44; 0.28	−0.08	−0.44; 0.28
	EWD	0.17	−0.10; 0.44	0.16	−0.11; 0.43	0.16	−0.11; 0.43
Relative density of fast-food outlets compared to all outlets	**Mindful eating domains**						
1600m	FE	2.12	−6.81; 11.05	1.49	−7.40; 10.38	1.49	−7.43; 10.41
	HSC	−2.19	−8.23; 3.86	−3.22	−9.19; 2.76	−3.18	−9.17; 2.81
	EWA	−8.81	−24.13; 6.50	−9.31	−24.44; 5.81	−9.37	−24.51; 5.77
	EWD	−4.86	−17.43; 7.71	−5.04	−17.44; 7.37	−5.11	−17.55′7.33
800m	FE	0.95	−5.60; 7.49	0.87	−5.62; 7.37	0.85	−5.65; 7.35
	HSC	2.12	−1.98; 6.22	2.62	−1.44; 6.68	2.63	−1.43; 6.70
	EWA	−1.73	−11.46; 8.00	−1.64	−11.27; 7.98	−1.83	−11.47; 7.81
	EWD	−3.47	−11.13; 4.18	−4.12	−11.68; 3.45	−4.10	−11.68; 3.47
400m	FE	4.70	−0.06; 9.46	4.16	−0.54; 8.87	4.17	−0.56; 8.90
	HSC	1.44	−1.71; 4.59	1.66	−1.46; 4.78	1.68	−1.45; 4.80
	EWA	3.14	−4.48; 10.76	2.29	−5.24; 9.82	2.31	−5.23; 9.85
	EWD	2.84	−3.04; 8.72	1.23	−4.61; 7.07	1.22	−4.62; 7.07

Note: FE= Focused Eating; HSc = Eating in response to Hunger and Satiety Cues; EwA = Eating with Awareness; EwD = Eating without Distraction.
Bold values indicate statistically significant coefficients.
Model 1 (raw model) is not adjusted. Model 2 is adjusted for sex, age, educational level, smoking status, and physical activity level. Model 3 (main model) is additionally adjusted for alcohol consumption and level of urbanization.
Interaction effects are shown from pick-a-point moderation analyses between the independent variable absolute and relative density of fast-food outlets in buffer zones of 1600, 800 and 400m and the moderator mindful eating (Focused Eating, Eating in response to Hunger and Satiety Cues, Eating with Awareness, Eating without Distraction) on the dependent variable snacks (g/d) in a sample of participants aged 55 years and older from the Longitudinal Aging Study Amsterdam (n = 1086).

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Authors' contributions

LHHW designed this study and collected the data on mindful eating and food intake. NdB performed the geographic analyses to construct food environment variables. LHHW conducted the statistical analyses. LHHW wrote the first draft with contributions from JM and NB. All authors reviewed and commented on subsequent drafts of the manuscript. All authors read and approved the final manuscript.

Declaration of competing interest

The authors declare that they have no competing interests.

Data availability

Data will be made available on request.

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Appendix. Results of adjusted sensitivity analysis including participants with extremely high energy intakes showing interaction effects from moderation analyses with the dependent variables saturated fat (en%) and snacks (g/d) (n = 1101)

		Saturated fat (en%)		Snacks (g/d)	
		B of the interaction effect	95% bootstrap CI	B of the interaction effect	95% bootstrap CI
Absolute density of fast-food outlets	**Mindful eating domains**				
1600m	FE	−0.004	−0.002; 0.001	**−0.05**	**−0.07; -0.03**
	HSC	−0.0001	−0.001; 0.001	**−0.02**	**−0.03; -0.01**
	EWA	−0.001	−0.003; 0.001	−0.02	−0.05; 0.01
	EWD	0.001	−0.001; 0.002	0.01	−0.02; 0.03
800m	FE	−0.001	−0.01; 0.003	**−0.15**	**−0.22; -0.09**
	HSC	−0.0001	−0.003; 0.003	**−0.07**	**−0.11; -0.02**
	EWA	−0.003	−0.01; 0.004	**−0.12**	**−0.22; -0.01**
	EWD	0.001	−0.004; 0.01	0.05	−0.03; 0.12
400m	FE	−0.01	−0.02; 0.01	**−0.53**	**−0.77; -0.29**
	HSC	−0.003	−0.01; 0.01	**−0.21**	**−0.35; -0.06**
	EWA	−0.01	−0.03; 0.01	**−0.38**	**−0.75; -0.02**
	EWD	0.002	−0.02; 0.02	0.13	−0.15; 0.41
Relative density of fast-food outlets compared to all outlets	**Mindful eating domains**				
1600m	FE	0.50	−0.06; 1.06	2.05	−7.24; 11.35
	HSC	0.06	−0.32; 0.43	−2.38	−8.56; 3.80
	EWA	−0.75	−1.71; 0.20	−7.17	−22.93; 8.59
	EWD	−0.74	−1.53; 0.04	−3.11	−16.06; 9.85
800m	FE	−0.03	−0.44; 0.38	1.40	−5.39; 8.18
	HSC	0.12	−0.14; 0.37	3.06	−1.17; 7.29
	EWA	−0.91	−1.52; 0.30	−1.19	−11.25; 8.87
	EWD	−0.22	−0.70; 0.03	−2.90	−10.80; 5.00
400m	FE	0.01	−0.29; 0.30	3.90	−1.00; 8.80
	HSC	0.07	−0.12; 0.27	1.55	−1.68; 4.78
	EWA	−0.26	−0.73; 0.22	2.22	−5.64; 10.08
	EWD	0.28	−0.09; 0.65	1.83	−4.26; 7.92

Note: FE= Focused Eating; EHS = Eating in response to Hunger and Satiety Cues; EwA = Eating with Awareness; EwD = Eating without Distraction.
Bold values indicate statistically significant coefficients.
Analyses are adjusted for sex, age, educational level, smoking status, physical activity level, alcohol consumption and level of urbanization.
Interaction effects are shown from pick-a-point moderation analyses between the independent variable absolute and relative density of fast-food outlets in buffer zones of 1600, 800 and 400m and the moderator mindful eating (Focused Eating, Eating in response to Hunger and Satiety Cues, Eating with Awareness, Eating without Distraction) on the dependent variable saturated fat (en%) and snacks (g/d) in a sample of participants aged 55 years and older from the Longitudinal Aging Study Amsterdam (n = 1101).

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