Sensory-Specific Satiety, the Variety Effect and Physical Context: Does Change of Context During a Meal Enhance Food Intake?

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Abstract

Food variety has been shown to increase food intake, and sensory-specific satiety (a relative decrease in pleasantness of a food as it is consumed) has been proposed as the mechanism through which variety increases consumption. The aim of this study was to investigate whether variation of eating context can add to experienced meal variety and hence increase consumption even further. A total of 128 participants were assigned to one of four conditions in which they first ate a specific food item (ad libitum) until satiated, after which they consumed a second course ad libitum of either the same or a different food in either the same context or in a different context. We hypothesized that, compared to eating the same food in the same context during the second course, introducing a different food item or changing the context for the second course increases consumption (of the second course), and changing both food and context enhances food intake to a greater degree than only changing the food or changing the context. Results indicated that food variety (introducing a different food) significantly increased consumption in the second course, but that a context switch did not enhance consumption. These results suggest that there is little reason to believe that sensory-specific satiety is context specific.

Keywords: Sensory-specific satiety, Sensory-specific satiation, Food variety, Context, Liking, Food intake
1. Introduction

An extensively studied aspect of eating behaviour is sensory-specific satiety (SSS). SSS refers to a decline in pleasantness derived from a food with its consumption, relative to other unconsumed foods (Rolls, 1986; Rolls, Rolls, Rowe, & Sweeney, 1981). According to this concept, a specific food item becomes less liked during its consumption, whereas there is little change in liking for other unconsumed foods. As the established satiety is food specific, SSS promotes the selection of a variety of foods (Rolls, 1986; Rolls, Rolls, Rowe, & Sweeney, 1981; Hetherington & Havermans, 2013). An important function of SSS then is to promote meal variety (Hetherington & Rolls, 1996). Conversely, meal variety itself is thought to delay SSS (Brondel, Lauraine, Van Wymbelbeke, Romer, & Schaal, 2009), and thus to encourage food intake (Hetherington, Foster, Newman, Anderson, & Norton, 2006; Brondel, Romer, et al., 2009). Indeed, meal variety has consistently been shown to increase consumption (Raynor & Osterholt, 2012; Remick, Polivy, & Pliner, 2009; Rolls, Rowe, et al., 1981).

Hetherington et al. (2006) demonstrated in a series of two experiments that asking participants to evaluate a different food item during consumption of a food delayed the expected decline in pleasantness of the consumed food and also led to an increased intake, as opposed to only eating and evaluating the same food item. Brondel, Romer et al. (2009) also demonstrated an attenuation of SSS when a variety of foods was introduced. In their experiment, participants were served fries and brownies with or without condiments (ketchup and whipped cream, respectively). The results of this experiment showed that participants ate more of the fries and brownies with (as opposed to without) condiments, and that this effect was associated with attenuated SSS for the fries and brownies. Reviewing 10 within-subjects design studies, McCrory, Burke, and Roberts (2012) found an average increase in food intake (energy or amount) of 22% when a meal was varied as opposed to the availability of just one food item. A recent meta-analysis corroborated these findings, reporting a small to medium effect of variety on intake (Embling, Pink, Gatzemeier, Price, Lee, & Wilkinson, 2021). Increased food intake due to food variety is commonly referred to as the ‘variety effect’ (Rolls, Rowe, et al., 1981).
Remick et al. (2009) reviewed 42 articles focusing on factors (internal and external) that possibly moderate this variety effect. They defined internal moderators as ‘individual difference or trait variables (i.e., stable characteristics of the individual) that have been hypothesized to influence the magnitude of the variety effect’ (p. 434), and external moderators as ‘aspects of the situation, including the food itself, which either enhance or diminish the variety effect’ (p. 434). They concluded that (according to the literature) internal factors (e.g., gender, weight and dietary restraint) do not seem to act as moderators of the variety effect, with the possible exception of old age (see also Embling, et al., 2021). In contrast, external factors such as particular properties of the food and the persons’ perception of the situation do seem to moderate the variety effect.

A particular external factor, which is not mentioned in the review of Remick et al. (2009), is the physical context of a meal. Eating does not take place in a vacuum, and hence it makes sense to presume that the precise context or setting in which one enjoys a meal affects the meal experience. Indeed, several studies have investigated the effect of contextual factors or meal situations on food intake, food choice, and food acceptance (García-Segovia, Harrington, & Seo, 2015; Meiselman, 2006; Rozin & Tuorila, 1993; Stroebele & De Castro, 2004). Rozin and Tuorila (1993) argued in a review that ‘a full understanding of human reactions to foods must place the moment of choice or ingestion in a rich context of both food and non-food influences’ (p. 18). Stroebele and De Castro (2004) summarized research findings concerning ambient influences on food intake and food choice, and concluded, based on these findings, that ambient factors (e.g., the number of people present, eating locations, lighting, et cetera) can influence food choice and consumption. Physical context has also been investigated as a factor which could influence the development of SSS (Garcia-Burgos, Secchiari, & Calviño, 2015). Garcia-Burgos et al. (2015) investigated the impact of physical context on the development of SSS, by assessing SSS for a familiar drink (a herbal tea beverage) in either a school cafeteria or a laboratory. Results of this study showed a lower overall magnitude of olfactory SSS in the cafeteria setting, suggesting that contextual variables can affect SSS.

The literature described above indicates that contextual factors can influence food intake, food
acceptance, food choice, and the development of SSS. In the present study we aimed to investigate
whether altering the physical context during a meal, by changing (elements of) the context in which a
meal is served (e.g., temperature, lighting, odour, sound), acts as a dishabituating stimulus that can
consequently lead to an increase in meal intake. This expected context-switch effect is based on the widely
held assumption that SSS is a form of habituation (in fact, the terms are often even used interchangeably,
see Epstein, Temple, Roemmich, & Bouton, 2009). Habituation has been defined as response decrement to
a repeatedly presented stimulus, which is not the result of sensory adaptation or sensory/motor fatigue.
Any stimulus that can be habituated, can also be dishabituated (recovery of responding after it has ceased
completely) (Rankin et al., 2009). With regard to SSS, this implies that introducing a dishabituating
stimulus after SSS has been established (cessation of food consumption) should restore responding to the
food just ingested (i.e. consumption of that food is resumed). Such a dishabituating stimulus can be a food
or non-food stimulus (Epstein et al., 2009), including an environmental context.

In order to test for a potential contextual effect as described above, a study design consisting of
four experimental conditions was developed. The four conditions differed from each other with regard to
food variety and context. Participants first ate a specific food item until satiated (first course), after which
they consumed a second course ad libitum of either the same or a different food in either the same context
or in a different context. Based on the findings of previous studies and the proposed contextual effect
described above, we hypothesized that, compared to eating the same food in the same context during the
second course, (1) introducing a different food item would increase consumption in the second course
(effectively replicating the ‘variety effect’), (2) changing the context for the second course would increase
consumption, and (3) changing both food and context would enhance meal intake to a greater degree than
only changing the food or changing the context (synergistic effect). We further expected that SSS would
develop for the food consumed in the first course. Note that our expected contextual effect is different
from the already investigated effect of external distractions on SSS and consumption (Bellisle & Dalix,
2001; Bellisle, Dalix, & Slama, 2004; Braude & Stevenson, 2014), since distractors are hypothesized to
delay the habituation process, while dishabituation takes place after responding to the stimulus has ceased
2. Methods

All study procedures were approved by the Maastricht University Ethical Research Committee of Psychology and Neuroscience (reference number: ERCPN-186_04_12_2017) and its proposal was preregistered on The Open Science Framework (https://osf.io/kgdf6).

2.1 Study Population

To estimate the appropriate number of subjects for the proposed study design, a sample size calculation was performed using G*Power 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007) for a 2 x 2 ANOVA (main effects and interactions), employing an $\alpha$ rejection criterion of 0.05 and 0.80 (1-$\beta$) power to detect a medium effect ($f = 0.25$). There were no prior studies to inform an effect size estimate for our context manipulation, but the size of the food variety effect can be substantial (Embling et al., 2021). Therefore, we considered a medium effect size for the context main effect and an interaction between food variety and a context switch to be relevant and reasonable. To be able to find such an effect, the power calculation indicated a total sample size of 128 participants.

The participants of this study were adult men and women (aged between 18 and 50 years), who were recruited via convenience sampling (e.g., posters and flyers, internet, advertisements, and other related sources). Participants aged above 50 years were excluded due to prior study results suggesting that the variety effect is different for older and younger adults (Remick et al., 2009). Participants were also excluded when they reported adhering to an energy restricting diet. Exclusion criteria further comprised medical or psychological disorders that affected eating (e.g., a history of cancer, gastrointestinal illness, celiac disease, dental surgery within the last three months, COPD, diabetes, or eating disorders) as well as disorders of taste and smell. Participants who indicated to experience difficulties with swallowing/eating,
who were hypersensitive or allergic to the food products used in the study or disliked the food items, who
were vegan, or pregnant/breastfeeding were also excluded from the study.

Candidate participants were screened before participation in the study to make sure they met the
inclusion criteria. They were also informed about the food items included in the study that they were
expected to taste and evaluate. In case a participant had a cold (which influenced his/her ability to taste
and smell), the scheduled appointment was rescheduled. When included in the study, participants were
given the necessary information about participation. The exact nature (i.e., the aim and hypotheses) of the
study was not disclosed until after the participant completed his/her participation in the study. Upon
completion of the participation, participants were compensated with a €5 gift voucher.

Table 1. Participants’ characteristics: mean age, mean hunger and thirst, mean intake in course 1, and sex
distribution for each condition (Var & Con = food variety and context switch). Values in parentheses
represent SD.

| Group          | Control | Variety | Context | Var & Con |
|----------------|---------|---------|---------|-----------|
| N              | 32      | 32      | 32      | 32        |
| Age (years)    | 26.8 (7.7) | 25.2 (6.7) | 28.6 (8.4) | 25.3 (5.3) |
| F(3, 124) = 1.58, p = .20, η² = 0.04 |
| Hunger (mm)    | 50 (24) | 50 (23) | 52 (18) | 48 (21) |
| F(3, 123) = 0.25, p = .86, η² = 0.01 |
| Thirst (mm)    | 58 (20) | 53 (25) | 55 (19) | 54 (20) |
| F(3, 123) = 0.34, p = .80, η² = 0.01 |
| Intake course 1 (g) | 41.0 (28.9) | 40.3 (31.2) | 46.1 (31.5) | 32.3 (24.8) |
| F(3, 124) = 1.23, p = .30, η² = 0.03 |
| Sex            | 14 men  | 10 men  | 12 men  | 7 men    |
| χ² = 3.75, p = .29 |
| 18 women       | 22 women| 20 women| 25 women|

A total of 130 participants participated in the study. Two participants were excluded from the data
analysis; one participant was not naïve to the study purpose and the other had difficulties eating the study
foods. This resulted in a total of 128 participants (43 male, 85 female), with a mean age of 26.5 ($SD = 7.2$), who were equally distributed over the four study conditions ($N = 32$). Participant characteristics per condition are summarized in table 1.

### Table 2. Experimental design and procedure (Var & Con = food variety and context switch).

| Condition          | Time → | First course          | Second course          |
|--------------------|--------|-----------------------|------------------------|
| Control (n=32)     |        | X[test food A]        |                        |
| Variety (n=32)     | Taste 1| X[test food A]        | Taste test 2           |
| Context (n=32)     |        | X[test food B]        | Y[test food A]         |
| Var & Con (n=32)   |        |                        | Y[test food B]         |

**Note.** Both taste tests were completed in the same room (i.e., X) as in which the participant received his/her first course. Further note that ‘X’ and ‘Y’ can refer to both laboratory rooms, and ‘A’ and ‘B’ can refer to all test foods.

### 2.2 Procedure, Measurements and Design

The participants in the study were tested individually. Each participant took part in an eating session at the laboratory, scheduled between 1 p.m. and 5 p.m. Participants were asked to eat a standard breakfast and/or lunch on the day of the laboratory session and not to eat or drink during the two hours prior to the session (except water, coffee or tea) to ensure that they experienced a certain degree of hunger. Participants were pseudo-randomly assigned to one of four experimental conditions of equal size: Control, Variety, Context, or Var & Con (see table 2 for the procedure of the experiment). Test foods and laboratory rooms (i.e., contexts) were completely counterbalanced within each of the four conditions. Participants in all conditions had free access to tap water during consumption, and were instructed not to use their phone, read a book, or engage in any other activities that could distract them from the instructed
On arrival at the laboratory, the participants were led to one of two laboratory rooms. These rooms had similar size (~11 m²), but were furnished in a way to create a different sensory experience. The features that differed between both rooms were the positioning of the participant (facing the wall or facing the door), the shape of the bowl in which the food was presented (round or rectangular), the placemat on which the food was placed, the decoration (e.g., plants or paintings), the scent in the room (different varieties of Ambi Pur Electrical house perfumes), and whether the seat of the chair was padded with a (thin) cushion. This was to ensure that the two eating contexts were clearly different from one another in terms of appearance, smell, and even feel, without one room being more distracting (in terms of sensory features) than the other.

In all conditions, participants received verbal and written information about the experimental procedure (not the experimental design and hypotheses) and signed an informed consent form. Then, they completed a demographics questionnaire containing questions about age, sex, and educational level (low, middle, or high), and rated their hunger and thirst on a 100-mm visual analogue scale (VAS), ranging from 0 (not at all hungry/thirsty) to 100 (extremely hungry/thirsty). Further, regardless of condition, the participant first tasted and evaluated four savoury foods and four sweet foods, which were matched (approximately) for caloric density, appearance, and texture: salty popcorn (AH zoute popcorn: 510 kcal per 100 g), cucumber (12 kcal per 100 g) and tomato (30 kcal per 100 g) on a stick, tomato juice (Appelsientje Zontomaatje: 18 kcal per 100 g), and grain crisps (Sunbreaks Wavy Grains sea salt flavour: 480 kcal per 100 g); sweet popcorn (AH zoete Popcorn: 425 kcal per 100 g), apple (58 kcal per 100 g) and grape (78 kcal per 100 g) on a stick, fruit juice (Appelsientje Multifruit: 43 kcal per 100 g / Appelsientje Multifruit volle smaak: 25 kcal per 100g), and banana crisps (Smaakt Bananenchips: 504 kcal per 100 g) (National Institute for Public Health and the Environment (RIVM), 2016).

Participants were instructed to evaluate the pleasantness of the eight food items and their desire to eat these food items (taste test 1) by rating ‘How much do you like this food right now?’ and ‘How strong is your desire to eat this food right now?’ on 100-mm line scales (VAS) ranging from 0 (not at all) to 100.
The eight food items (all of them labelled with a three-digit number) were presented by the experimenter to the participant one at a time, together with a sheet containing the corresponding ‘pleasantness’ and ‘desire to eat’ scales for the food item, in order to minimize distraction that could be caused by the presence of the other foods. After completion of the taste test, the participant received a large bowl of popcorn (sweet or salty) or crisps (grain or banana) (counterbalanced between participants) and was instructed to “eat until pleasantly full”. The food was weighed before and after consumption, and the weights were noted to calculate the amount of food consumed. During this ad libitum consumption, the experimenter was not present. When the participant had finished, wanted to have more of the food or water, or had any questions, he/she could contact the experimenter using a wireless communication system (a radiotelephone). Directly after the ad libitum consumption of the popcorn or crisps the participant was again instructed to taste and evaluate all eight aforementioned food items (taste test 2), which were presented to the participant following the same procedure as the first taste test.

After the second taste test, all participants received a second serving (or course) of either the same test food or a different test food (crisps in case the test food for the first course was popcorn; popcorn if the test food for the first course was crisps; salty when first course was sweet and vice versa) for ad libitum consumption. The food was again weighed before and after consumption. The second course was served in either the same room or a different room. In condition ‘Control’ (no food variety, no context switch) the participant received the same test food in the second course and stayed in the same room. Condition ‘Variety’ (food variety, no context switch) is equal to condition ‘Control’ except that participants in this condition received a different test food in the second course. Participants in condition ‘Context’ (no food variety, context switch) received the same test food in the second course, but were moved to the other laboratory room. Participants in condition ‘Var & Con’ (food variety and context switch) received a different test food and were also moved to the other laboratory room. Participants who were moved to a different room were simply told that the second part of the experiment would take place in a different room. None of the participants asked questions about this. During this second course the experimenter was also not present. The participant could contact the experimenter using the
radiotelephone when he/she had finished, wanted to have more of the food or water, or had any questions. After the participants had finished the second course they were asked what they thought the study was investigating. For this purpose, participants answered the question: ‘What do you think this experiment is about?’. Six of the participants correctly guessed the aim of the study regarding SSS. These participants were included in the analyses since excluding these participants from the analyses did not affect the results.

2.3 Data analysis

We checked the equivalence of the four groups in terms of participant age, initially rated hunger and thirst levels, and amount consumed in the first course with separate one-way ANOVAs with Group (Control, Variety, Context, Var & Con) as between-subjects factor. No significant differences between groups were found (see table 1). We further checked the equivalence of the four groups in terms of sex distribution with a Chi-square test (see table 1), which also showed no significant differences.

Development of SSS as the result of the first course was analysed by calculating differences between the ratings of pleasantness and desire to eat the food items of taste test 1 and taste test 2 for the test food and the uneaten control foods for all participants. For the uneaten foods, these difference scores were averaged into a single difference score. We used a two-way ANOVA with Group (Control, Variety, Context and Var & Con) and Food (eaten vs. control) as factors to test the development of SSS. Note that the food pleasantness ratings are viewed as the primary outcome variable for determining SSS. We further intended to explore to what degree the expected decrease in pleasantness and desire ratings for the test food generalized to the uneaten foods that shared either textural, visual (i.e., the texture and appearance of the uneaten popcorn or crisps) or taste (either sweet or savoury depending on the taste of the test food consumed) characteristics. These exploratory analyses can be found in our supplemental materials on The Open Science Framework (https://osf.io/54gaf/). The data of two participants were removed for the SSS and ‘desire to eat’ analyses due to missing values for one of the control foods.

To test the potential effects of food variety and a context switch on consumption, the amount of
food eaten in the second course was calculated by averaging the volume (weight) and amount (energy in kcal) of the foods consumed for each condition. Differences between the experimental conditions were then analysed using a 2 (Context: same or different) x 2 (Food: same or different) ANOVA. This ANOVA was the key test for examining the three hypotheses outlined in the Introduction section.

Note that for the analyses to assess SSS (given course 1) and a potential effect on intake due to a context or food switch (given course 2), the relevant data were first screened for error outliers (e.g., due to incorrect data entry), interesting outliers (e.g., unexpected extreme values not due to error), and influential outliers (data points outside a mean ± 3 SD range) as recommended by Aguinis, Gottfredson, and Joo (2013). No error outliers were present. Four (potentially) influential outliers were winsorized.

All analyses were performed in R, using the RStudio® software package and the packages ‘pastecs’, ‘ggplot2’, ‘ez’, ‘reshape’, ‘reshape2’, ‘psych’, ‘car’, ‘gmodels’, and ‘plyr’ (RStudio Team, 2016). All effects are reported as significant at $p < .05$. Effect sizes ($\eta^2_p$) were calculated using the spreadsheet provided by Lakens (2013). The anonymized raw data and the R scripts used for the analyses are available on The Open Science Framework (https://osf.io/54gaf/).

### 3. Results

A two-way mixed ANOVA (group x food) for pleasantness ratings (the primary outcome variable for determining SSS) showed only a significant main effect of food [$F(1, 122) = 19.05, p < .0001, \eta^2_G = .07$]. There was no significant main effect of group [$F(3, 122) = 1.20, p = .31, \eta^2_p = .03$], and no interaction effect [$F(3, 122) = 0.84, p = .47, \eta^2_G = .01$], indicating that SSS was present in each of the conditions.

Next to assessing SSS in terms of change in pleasantness, we also tested whether there was a significant change in desire ratings for the consumed foods as compared to the control foods (two-way ANOVA: group x food). This ANOVA showed the same pattern as the ANOVA for pleasantness ratings; only a significant main effect of food [$F(1, 122) = 53.18, p < .0001, \eta^2_G = .16$], indicating that desire ratings to
eat the consumed foods dropped significantly more than these ratings for the control foods in all
conditions. There was no significant effect of group \([F(3, 122) = 0.96, \ p = .41, \ \eta_p^2 = .02]\), and no
interaction \([F(3, 122) = 2.01, \ p = .12, \ \eta_p^2 = .02]\). See figure 1 and 2 for mean changes (and 95%
confidence intervals) for pleasantness ratings and desire ratings per condition and food (eaten vs. control
foods). See the supplemental materials for means and SD for pleasantness and desire difference scores per
condition for eaten and control foods. See also the supplemental materials for pretest pleasantness and
desire ratings for eaten and control foods for each condition separately.

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Please insert Figures 1 and 2 here

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A two-way ANOVA testing the effect of food variety and a context switch on intake in the second
course in grams showed only a significant main effect of food variety \([F(1, 124) = 11.14, \ p < .01, \ \eta_p^2 =
0.08]\), while an effect of context \([F(1, 124) = 1.34, \ p = .25, \ \eta_p^2 = 0.01]\), and an interaction \([F(1, 124) =
0.71, \ p = .40, \ \eta_p^2 = 0.01]\) were absent. For intake in kcal in course 2, the two-way ANOVA indicated a
similar pattern. Only food variety had a significant effect \([F(1, 124) = 10.97, \ p < .01, \ \eta_p^2 = 0.08]\) on intake
in kcal (no effect of context \([F(1, 124) = 1.22, \ p = .27, \ \eta_p^2 = 0.01]\), or an interaction \([F(1, 124) = 0.75, \ p =
.39, \ \eta_p^2 = 0.01]\)). Figures 4 and 5 show mean intake (and 95% confidence intervals) in course 2 per
condition in grams and kcal, respectively (means and SD for intake in grams as well as intake in kcal can
be found in the supplemental materials). These results indicate that only food variety enhanced intake in a
second course, while a context switch did not have any influence on consumption.¹

¹ Based on a reviewer suggestion we explored whether gender influenced the reported results. A three-way ANOVA
(gender x food variety x context) revealed neither a main effect of gender, nor any interaction effects with gender (all
p’s > .05).
4. Discussion

In this experiment, we investigated SSS and the effect of food variety and a context switch on consumption (the primary aim of the study). The results of this study showed that pleasantness and desire ratings for consumed food items (in course 1) dropped significantly more after consumption than these ratings for control foods, thereby replicating SSS. Furthermore, we replicated the variety effect as our results showed that introducing a different food increased consumption in the second course. We did not find any evidence that a context switch enhances consumption, which implies that SSS is not context-specific. The results indicate that SSS develops specifically for the food that is consumed, and not for the situation in which this food is consumed (i.e., it is a truly sensory ‘specific’ satiation; see also Higgs, Williamson, Rotshtein, & Humphreys, 2008). Next to that, if SSS is indeed a form of habituation, implying it is possible to dishabituate SSS, the context switch should have resulted in a recovery of consumption when the same food was presented in a different context. The absence of a dishabituating contextual effect in our study suggests either that SSS is not a form of habituation (see also Hetherington & Havermans, 2013), or that the dishabituating stimulus (i.e., the switch in context) was not salient enough.

The absence of a contextual effect might be due to the relatively subtle context manipulation. The context manipulation in this study was mainly produced by altering certain details in two fairly similar laboratory rooms (e.g., a rug on the floor versus no rug on the floor, or a cushion on the chair versus no cushion on the chair), in order to create equally ‘distracting’ contexts, without one of these being more or less associated with food consumption (e.g., a dining room). One might argue that these differences may
have been too subtle to have been noted by participants, and therefore they did not experience a contextual

difference. In this study, we did not check whether participants noticed the differences between the rooms

and whether they experienced it as a different ‘ambience’. It is not known whether one has to be

consciously aware of this ‘context switch’ for it to have an effect on consumption. However, considering

that participants had to actively walk to another room makes it hard to contend that they might have been

oblivious to the switch in context itself. Nonetheless, future research should examine whether a stronger

(and more discernible) context manipulation does affect food intake, and whether its noticeability is key

for its effectiveness. Another limitation of this study is that the ‘meal’ in this study does not necessarily

resemble what is regarded as a typical meal. The foods in the study are not alien to the participants, but the

way in which they were presented (in two ‘snack’ courses) might have been, which affects the external

validity of the study results.

In conclusion, this study replicated the effect of food variety on consumption and demonstrated

SSS and a relative decrease in desire to consume a food just eaten until pleasantly full. A change in

context during the ‘meal’ did not enhance intake. Since the absent effect of our contextual manipulation

on food intake might be due to the subtlety of the manipulation, future research should examine whether a

stronger and more noticeable context change could have an effect on consumption.

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Author Contributions
The authors’ contributions were as follows: AEMH, CN, AB and RCH designed the research; AEMH, IMJL, and BB conducted the experiment; AEMH analyzed the data and wrote the manuscript in consultation with CN and RCH; all authors read and approved the submitted revised manuscript.
Aguinis, H., Gottfredson, R. K., & Joo, H. (2013). Best-Practice Recommendations for Defining, Identifying, and Handling Outliers. *Organizational Research Methods, 16*(2), 270–301. https://doi.org/10.1177/1094428112470848

Bellisle, F., & Dalix, A. M. (2001). Cognitive restraint can be offset by distraction, leading to increased meal intake in women. *American Journal of Clinical Nutrition, 74*(2), 197–200.

Bellisle, F., Dalix, A. M., & Slama, G. (2004). Non food-related environmental stimuli induce increased meal intake in healthy women: Comparison of television viewing versus listening to a recorded story in laboratory settings. *Appetite, 43*(2), 175–180. https://doi.org/10.1016/j.appet.2004.04.004

Braude, L., & Stevenson, R. J. (2014). Watching television while eating increases energy intake. Examining the mechanisms in female participants. *Appetite, 76*, 9–16. https://doi.org/10.1016/j.appet.2014.01.005

Brondel, L., Lauraine, G., Van Wymelbeke, V., Romer, M., & Schaal, B. (2009). Alternation between foods within a meal. Influence on satiation and consumption in humans. *Appetite, 53*(2), 203–209. https://doi.org/10.1016/j.appet.2009.06.009

Brondel, L., Romer, M., Van Wymelbeke, V., Pineau, N., Jiang, T., Hanus, C., & Rigaud, D. (2009). Variety enhances food intake in humans: Role of sensory-specific satiety. *Physiology & Behavior, 97*(1), 44–51. https://doi.org/10.1016/j.physbeh.2009.01.019

Embling, R., Pink, A. E., Gatzemeier, J., Price, M., Lee, M. D., & Wilkinson, L. L. (2021). Effect of food variety on intake of a meal: a systematic review and meta-analysis. *Am J Clin Nutr, 0*, 1–26. https://doi.org/10.1093/ajcn/nqaa352

Epstein, L. H., Temple, J. L., Roemmich, J. N., & Bouton, M. E. (2009). Habitation as a determinant of human food intake. *Psychological Review, 116*(2), 384–407. https://doi.org/10.1037/a0015074

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods,*
Garcia-Burgos, D., Secchiari, F., & Calviño, A. (2015). Is sensory-specific satiety for a bitter-sweet infusion modulated by context? *Physiology and Behavior, 140*, 180–187. https://doi.org/10.1016/j.physbeh.2014.12.035

García-Segovia, P., Harrington, R. J., & Seo, H-S. (2015). Influences of table setting and eating location on food acceptance and intake. *Food Quality and Preference, 39*, 1–7. https://doi.org/10.1016/j.foodqual.2014.06.004

Hetherington, M. M., Foster, R., Newman, T., Anderson, A. S., & Norton, G. (2006). Understanding variety: Tasting different foods delays satiation. *Physiology & Behavior, 87*(2), 263–271. https://doi.org/10.1016/j.physbeh.2005.10.012

Hetherington, M., & Havermans, R. C. (2013). Sensory-specific satiation and satiety. In J. E. Blundell & F. Bellisle (Eds.), *Satiation, satiety and the control of food intake. Theory and practice* (pp. 253–269). Cambridge: Woodhead Publishing Ltd. https://doi.org/10.1533/9780857098719.4.253

Hetherington, M. M., & Rolls, B. J. (1996). Sensory-specific satiety: Theoretical frameworks and central characteristics. In E. D. Capaldi (Ed.). *Why we eat what we eat: The psychology of eating* (pp. 267–290). Washington, DC: American Psychological Association. https://doi.org/10.1037/10291-010

Higgs, S., Williamson, A. C., Rotshtein, P., & Humphreys, G. W. (2008). Sensory-specific satiety is intact in amnesics who eat multiple meals. *Psychological Science, 19*(7), 623–628. https://doi.org/10.1111/j.1467-9280.2008.02132.x

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. *Frontiers in Psychology, 4*, 1–12. https://doi.org/10.3389/fpsyg.2013.00863

McCrorry, M. A., Burke, A., & Roberts, S. B. (2012). Dietary (sensory) variety and energy balance. *Physiology & Behavior, 107*(4), 576–583. https://doi.org/10.1016/j.physbeh.2012.06.012

Meiselman, H. L. (2006). The role of context in food choice, food acceptance and food consumption. In R. McCrorry, M. A., Burke, A., & Roberts, S. B. (Eds.), *Dietary (sensory) variety and energy balance*. *Physiology & Behavior, 107*(4), 576–583. https://doi.org/10.1016/j.physbeh.2012.06.012
Shepherd & M. Raats (Eds.), *The Psychology of Food Choice* (pp. 179–199). Wallingford: CABI. https://doi.org/10.1079/9780851990323.0179

National Institute for Public Health and the Environment (RIVM) (n.d.), NEVO online version 2016/5.0, (Bilthoven: RIVM, 2016).

Rankin, C. H., Abrams, T., Barry, R. J., Bhatnagar, S., Clayton, D. F., Colombo, J., … Thompson, R. F. (2009). Habituation revisited: An updated and revised description of the behavioral characteristics of habituation. *Neurobiology of Learning and Memory*, 92(2), 135–138. https://doi.org/10.1016/j.nlm.2008.09.012

Raynor, H. A., & Osterholt, K. M. (2012). Greater variety of fruit served in a four-course snack increases fruit consumption. *Appetite*, 59(3), 662–667. https://doi.org/10.1016/j.appet.2012.08.003

Remick, A. K., Polivy, J., & Pliner, P. (2009). Internal and external moderators of the effect of variety on food intake. *Psychological Bulletin*, 135(3), 434–451. https://doi.org/10.1037/a0015327

Rolls, B. J. (1986). Sensory-specific Satiety. *Nutrition Reviews*, 44(3), 93–101. https://doi.org/10.1111/j.1753-4887.1986.tb07593.x

Rolls, B. J., Rolls, E. T., Rowe, E. A., & Sweeney, K. (1981). Sensory specific satiety in man. *Physiology and Behavior*, 27(1), 137–142. https://doi.org/10.1016/0031-9384(81)90310-3

Rolls, B. J., Rowe, E. A., Rolls, E. T., Kingston, B., Megson, A., & Gunary, R. (1981). Variety in a meal enhances food intake in man. *Physiology & Behavior*, 26(2), 215–221. https://doi.org/10.1016/0031-9384(81)90014-7

Rozin, P., & Tuorila, H. (1993). Simultaneous and temporal contextual influences on food acceptance. *Food Quality and Preference*, 4(1–2), 11–20. https://doi.org/10.1016/0950-3293(93)90309-T

R Studio Team. (2016). RStudio: Integrated Development for R (Version 1.1.383) [Computer Software]. Boston, MA: RStudio, Inc. Available from http://www.rstudio.com/.

Stroebele, N., & De Castro, J. M. (2004). Effect of ambience on food intake and food choice. *Nutrition*, 20(9), 821–838. https://doi.org/10.1016/j.nut.2004.05.012
Figure captions

Figure 1. Mean change in pleasantness ratings for all conditions in mm (Var & Con = food variety and context switch). Error bars represent 95% confidence intervals.

Figure 2. Mean change in desire ratings for all conditions in mm (Var & Con = food variety and context switch). Error bars represent 95% confidence intervals.

Figure 3. Mean intake per condition in course 2 in grams. Error bars represent 95% confidence intervals. (Var & Con = food variety and context switch)

Figure 4. Mean intake per condition in course 2 in kcal. Error bars represent 95% confidence intervals. (Var & Con = food variety and context switch)
Ethical Statement

All study procedures were approved by the Maastricht University Ethical Research Committee of Psychology and Neuroscience (reference number: ERCPN-186_04_12_2017). All participants in the study gave informed consent before taking part in the study.