Scholars LITERATURE

Journal of Food and Nutritional Health

Research Article

DOI: https://doi.org/10.47275/2692-5222-107
Volume 2 Issue 1

Sensory Specific Desires Affect and are Affected by Actual Snack Choice

Mette Duerlund*, Barbara Vad Andersen, and Derek Victor Byrne

Department of Food Science, Faculty of Technical Sciences, Food Quality Perception & Society, Aarhus University, Denmark

Abstract

Background and Aims: Snacking contributes to additional calories on top of what is consumed during meals. To better understand drivers of snack choice, we investigated subjective appetite and sensory specific desires (SSD). The overall purpose of this study was to 1) Study the effects of subjective appetite sensations on actual snack choice, 2) Study if SSDs were affected by actual choice and intake of snack.

Methods: A total of 112 participants answered a questionnaire about subjective appetite and chose one of two snacks: chips, representing a salty sensory taste profile or chocolate, representing a sweet sensory taste profile.

Results: Results revealed that an interaction between Salty desire and Sweet desire showed significant effect for both snack choice options. Results further revealed a significant decrease in Salty desire only after chips intake (salty taste profile) and a significant decrease in Sweet desire only after chocolate intake (sweet taste profile). Sweet desire remained the same for chips choosers and Salty desire remained the same for chocolate choosers.

Conclusions: Findings demonstrate the power of food choice to alter and to fulfil sensory desires. It is concluded that SSDs are important drivers of actual snack choice and that snacks having the desired sensory characteristics can satisfy these desires upon consumption. These findings provide further insights into the role that SSDs play in snacking behavior.

Keywords: Consumer; Snack; Sensory Specific Desire; Choice; Behavior; Hedonic Hunger

Correspondence to: Mette Duerlund, Department of Food Science, Faculty of Technical Sciences, Food Quality Perception & Society, Aarhus University, Denmark; E-mail: m_duerlund@hotmail.com

Citation: Duerlund M, Andersen BV, Byrne DV (2021) Sensory Specific Desires Affect and are Affected by Actual Snack Choice. J Food Nutr Health, Volume 2:1. 107. DOI: https://doi.org/10.47275/2692-5222-107

Received: January 27, 2021; **Accepted:** February 10, 2021; **Published:** February 16, 2021

Introduction

Food and snack choices are influenced by numerous factors including individual, social and environmental factors [1-4]. The processes and occurrences around food choice behavior are hence complex, but nevertheless important in order to better understand some of the underlying patterns behind eating behaviors in general. Snacking refers to the act of eating a snack, often in-between meals, and snacking is known to contribute to (substantial) additional calories on top of what is consumed during main meals [1,5-7]. Popular and frequent food preferences for snacks in general include sweet, salty and fatty snack options [1,8]. Motivations and initiations to snack contain many underlying factors including homeostatic and non-homeostatic factors. Homeostatic factors comprise the processes behind e.g. hunger and satiety to signal a physiological need and thus a motivation to eat or not to eat [1,9,10] and non-homeostatic factors include seeking palatable hedonic foods to stimulate and fulfil desires and thus reflect a reward-seeking behavior and motivation rather than a physiological need [11-15]. Especially non-homeostatic influences like hedonic eating and reward-seeking behavior have gained increasing focus within snacking and eating behavior research [1,8,16,17].

Choosing a snack is often made as an impulsive decision, perhaps even instinctively. For instance, research shows that we are aware of only a fraction of our daily food decisions[18-20]. This leads us to conduct more observational and choicer research in order to favor and validate consumers' actual choice behaviors, thus closer to real life rather than just collecting imaginary and intended choices on paper [2,21].

The present study situates itself in the research area of subjective appetite and food behavior and in the pursuit to better understand some of the individual processes and determinants in actual snack choice behavior, we here look closer into the concept of sensory specific desires (SSD) [16]. SSD refers to an intrinsic motivation to eat now or in the near future with a general desire for a certain taste category, e.g. salty, sweet, fatty, savory, spicy or bitter. SSDs both include and go beyond specific food items [22,23], whereas sensory specific satiety (SSS) refers to a decline in pleasantness of a specific food eaten relative to a food not eaten, often evaluated via liking and wanting [24-27]. Liking and wanting evaluations hence often relate to the specific food eaten, whereas specific desires can be useful in the further prediction of food choice (e.g. snacks with pronounced sensory characteristics) and eating behavior. The concept of SSD in this paper relates to the

motivation to snack, specifically how SSDs affect actual snack choice and furthermore how snack choices are made to satisfy subjective desires. Several studies have approached the same topic but utilized different methodology, e.g. by looking at changes in desires over the course of a meal (often predefined and standardized meal) and investigating how additional desires develop [23,28,29]. Yet, no one, to our best knowledge, has included choice behavior and observed how desires are satisfied via choice. This research study thus seeks to examine the relationship between subjective sensations and actual snack choice, particularly focusing on SSDs' effect on snack choice and snack choices' effect on satisfying SSDs.

The overall purpose of this research study was to investigate the relationship between SSDs and actual snack choice. Specifically, the study aimed to:

- Study the effects of subjective appetite sensations on actual snack choice.
- Study if sensory specific desires are affected by actual choice and intake of snack.

Related to the first aim, it was hypothesized that specific appetite sensations would contribute to actual snack choice in the late afternoon, with in particular SSDs showing the greatest effects. Related to the second aim, it was hypothesized that actual snack choice and intake would alter SSDs such that the choice would reduce and fulfil the specific sensory desire from pre choice to post choice. The study involved a consumer study with a questionnaire including an actual snack choice. As such, this research study collected actual snack choice data with an implicit behavioral measure for choice in order to represent a real actionable choice and intake. Findings from the present research study can provide further insights into eating behaviors as to how and why we choose snacks and the role that SSDs play in snacking behavior.

Materials and Methods

Recruitment and Participants

Participants (n_{total} = 112) were recruited from Aarhus University, School of Business and Social Sciences (BSS), Denmark. Participants comprised Bachelor students and inclusion criteria included being between 18 and 30 years old with a willingness to eat a snack as part of the research study. Exclusion criteria included having any food allergies. Table 1 shows the participant characteristics. All participants gave their written consent prior to the commencement of the study. Ethical approval was not required for this type of study according to the National Committee on Health Research Ethics in Denmark (Section 14 (2) in the Committee Act) [30].

Questionnaire

The online questionnaire consisted of nine questions within the appetite space, i.e. Hunger, Fullness, Desire to snack, Sweet desire, Salty desire, Fatty desire, Energized, Concentration and Sleepiness. These variables were in focus because of their relation to the appetite space, as previously established by the authors, showing that these sensation variables vary in intensity dependent on specific food intake and time after food intake [16,31,32]. The variables include both homeostatic variables such as Hunger and Fullness and non-homeostatic variables such as desires and more energy-related sensations like Concentration and Sleepiness. All variables were believed to possibly play a role in snack choice behavior, and in this study, we examine the relationship between these sensation variables and snack choice behavior. SSDs were evaluated as a single question for each taste quality (sweet, salty, fatty), validated in assessment of appetite sensations [33], with focus on a subjective general sweet, salty or fatty desire, as opposed to a desire for a specific sweet, salty or fatty food item. Furthermore, we did not wish for consumers to dissect or be too analytical about their subjective desire ratings in anactual snack choice situation. The response variables were evaluated in randomized order both pre and post snack choice on a 10 cm visual analogue scale (VAS) using Compusense® Cloud software (Compusense Inc., Guelph, Ontario, Canada). The scale ranged from 0, anchored "not at all" to 10, anchored "very much". Table 2 displays the exact phrasings of the nine appetite questions. The online questionnaire was set up to work on different size devices. In between evaluating the nine response variables, the questionnaire included the choice of a snack with a forced 1-minute delay build in before continuing the questionnaire, avoiding people still eating during the second part of the questionnaire. Additionally, participants filled out demographic questions about gender, age, height and weight.

Table 1: Participant characteristics.

Characteristics	
n_{total}	112
Males/females	31/81
Age (years)	22.8 ± 2.6 (18-30) *
Weight (kg)	67.7 ± 11.1 (48-110) *
Height (cm)	173.0 ± 9.0 (156-200) *
BMI[1] (kg/m^2)	22.5 ± 2.6 (16.7- 32.1) *

* Mean ± standard deviation (range); [1]BMI= body mass index

The response variables were evaluated in randomized order both pre and post snack choice on a 10 cm visual analogue scale ranging from 0, anchored "not at all" to 10, anchored "very much".

Table 2: Questionnaire response variables with their exact question phrasings.

Variable	Question phrasing
Hunger	"How hungry are you right now?"
Fullness	"How full are you right now?"
Desire to snack	"How much do you desire to snack something right now?"
Sweet desire	"How much do you desire to eat something sweet right now?"
Salty desire	"How much do you desire to eat something salty right now?"
Fatty desire	"How much do you desire to eat something fatty right now?"
Energized	"How energetic are you right now?"
Concentration	"How is your concentration right now?"
Sleepiness	"How sleepy do you feel right now?"

Snack Samples

Two common snack products commercially available on the Danish marked were chosen for the study. The two snacks included a 45g mini bag of M&M's plain chocolate (Mars Incorporated, McLean, Virginia, United States) and a 25g mini bag of KiM's salted chips (Orkla Confectionary and Snacks Danmark A/S, Søndersø, Denmark). To avoid any bias related to portion size, the two snacks were selected to be visually comparable rather than to be iso-caloric. The chocolate snack was selected to represent a dominant sweet sensory taste profile and the chips snack was selected to represent a dominant salty sensory taste profile. Both snacks could be considered to have a fatty sensory taste profile as well. Both snacks were selected and assumed to belong to an unhealthy hedonic palatable snack category, attempting to avoid any bias related to health-consciousness, self-control factors or gender factors, which is demonstrated to be key factors for the healthier food choices [16,18].

Procedure

The study comprised a questionnaire study including a snack

choice. Participants were told that the study was about their current appetite and no information was given about the overall purpose of the study to investigate the relationship between SSDs and actual snack choice. The study took place between 3:30 p.m. and 5:00 p.m. in the afternoon under the assumption that people's willingness to snack was high within this time period and furthermore under the assumption that it was not too close to lunch or dinner either. These considerations were done to avoid results being affected by main meal intake, but instead reflect a likely snacking situation. After agreeing to partake, the participants filled in an online questionnaire via an URL link on their own device (laptop, iPad or smartphone). After completing the first half of the questionnaire, participants were instructed to choose one of two available snacks, which they would like to eat immediately. Participants then consumed the whole self-chosen snack, before completing the second half of the questionnaire. The study took approximately 20-30 minutes in total and each participant undertook the study once.

Data Analysis

Data on self-reported weight and height were used to calculate body mass index (BMI): weight (kg)/ (height (m))^2. Repeated measures ANOVA option REML (Restricted Maximum Likelihood) was applied to analyze time effects as well as the time*choice interaction effects from pre snack intake to post snack intake. *P*-values < 0.05 were considered statistically significant and Bonferroni's test was applied to account for pair wise comparisons. Effect sizes were examined using Cohen's d values [34]. To examine the main explanatory variables and predicted probability values for snack choice, binomial logistic regression models were applied separately for each snack choice response [35]. All pre snack appetite variables as well as background variables (gender and BMI) functioned as the explanatory variables and the snack choice as the binary response type (choice/no choice, 1/0). Models were iteratively reduced in case of non-significant effects to produce more stable models in finding the significant explanatory variables. Levene's test was applied to assess the equality of variances for the significant explanatory variables. All statistical analyses were carried out using XLSTAT by Addinsoft, version 2019.2. (XLSTAT, Long Island, NY, USA) [36]. Hypotheses and analytic plan were pre-specified before data collection.

Results

Explanatory Variables for Snack Choice

From the two snack options, 48.2% of the consumers chose the chocolate snack and 51.8% of the consumers chose the chips snack. In order to examine the main explanatory variables for consumers' choice, we applied binomial logistic regression models on variables and choice data. Results showed that neither gender nor BMI had an effect on snack choice. Figure 1 displays the significant pre snack intake variables' effect on the two snack choice responses, by depicting standardized coefficient values (COEF) including 95% confidence intervals (CI). From the evaluated pre snack appetite variables, the iteratively reduced model revealed that Salty desire as well as the interaction between Salty desire and Sweet desire showed significant effects for both snack choices. For the chocolate choice, Salty desire (X^2 = 16.93, COEF = -1.55, 95% CI [-2.29, -.81], p< 0.0001) had a negative effect on choice, whereas the interaction Sweet desire*Salty desire (X^2 = 6.24, COEF = 1.12, 95% CI [.24, 1.99], p = 0.012) had a positive effect. For the chip's choice, Salty desire (X^2 = 17.04, COEF = 1.55, 95% CI [.82, 2.29], p< 0.0001) had a positive effect, whereas the interaction Sweet desire*Salty desire (X^2 = 6.33, COEF = -1.13, 95% CI [-2.01, -.25], p = 0.012) had a negative effect. Sweet desire on its own did not show significant explanatory effect for any of the choices. None of the other response variables (Hunger, Fullness, Desire to snack, Fatty desire, Energized, Concentration and Sleepiness) were explanatory for snack choice in this research study.

Figure 2 visually depicts the predicted probability values (extracted from the binomial logistic regression models) for choice dependent on the significant interaction effect found between Salty desire (●) and Sweet desire (●). The figure shows that consumers with high Salty desire are more likely to choose chips for snacks, if Sweet desire is low at the same time, and consumers with low Salty desire are more likely to choose chocolate, if Sweet desire is high at the same time. Levene's test showed no significant difference in variances for Sweet desire and Salty desire (p = 0.47).

Snack Choice's Effect on Response Variables

Across both choices (n_{total} = 112), all evaluated variables showed significant main effect of time: Hunger decreased (F = 51.96, p< 0.0001, d = 0.6), Fullness increased (F = 33.01, p< 0.0001, d = 0.5), Desire to snack decreased (F = 91.78, p< 0.0001, d = 1.0), Sweet desire decreased (F = 89.94, p< 0.0001, d = 1.0), Salty desire decreased (F = 15.13, p< 0.0001, d = 0.4), Fatty desire decreased (F = 36.62, p< 0.0001, d = 0.6), Energized increased (F = 45.20, p< 0.0001, d = 0.7), Concentration increased (F = 9.03, p = 0.003, d = 0.3) and Sleepiness decreased (F = 15.85, p< 0.0001, d = 0.4).

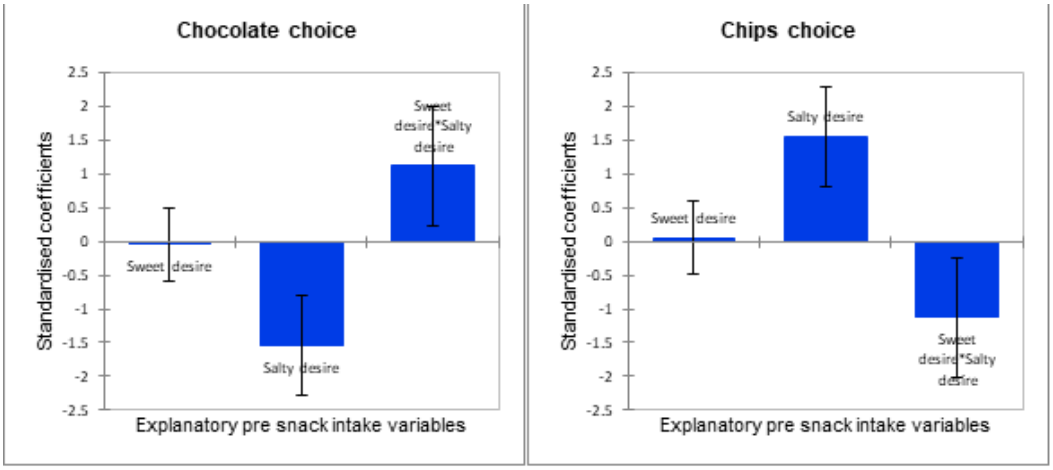

Figure 1: Significant explanatory pre snack intake variables for chocolate choice and chips choice illustrating standardized coefficient values including 95% confidence intervals.

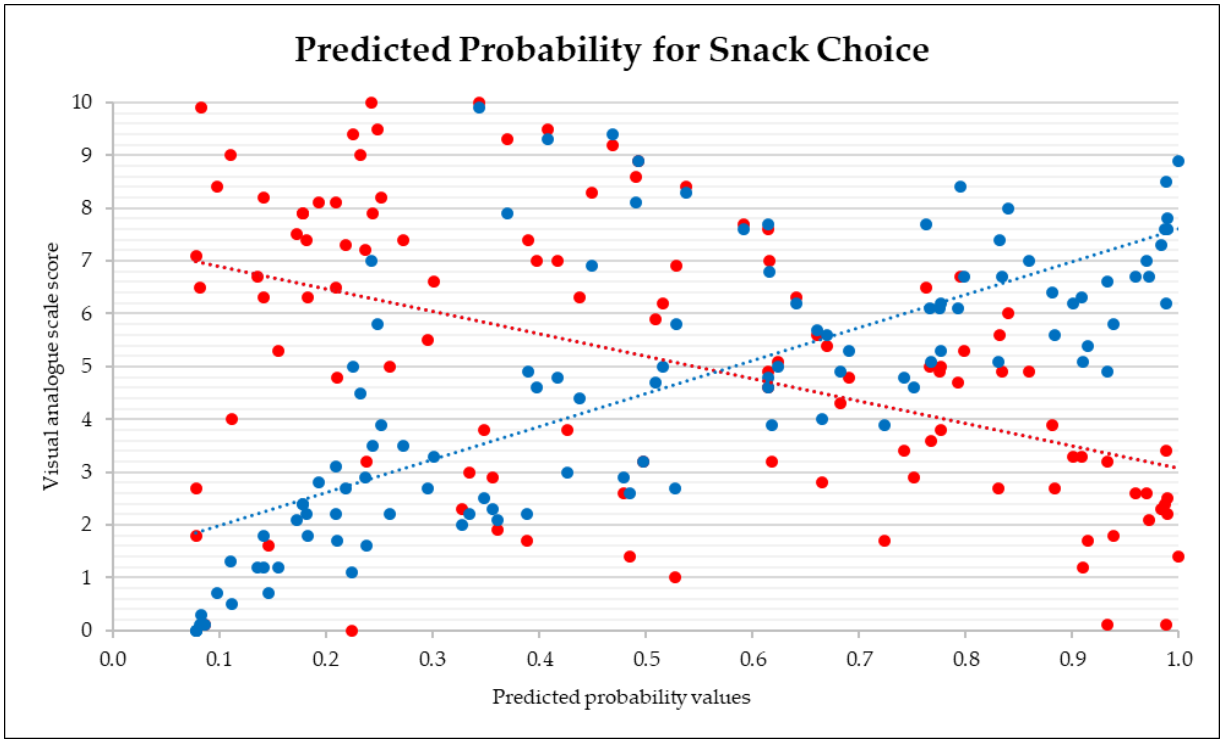

Figure 2: Predicted probability for snack choice illustrating the interaction effect between Salty desire (●) and Sweet desire (●). Predicted probability values from explanatory continuous data in logistic regression models range from 0 to 1. Values closer to 0, predicts chocolate choice outcome. Values closer to 1, predicts chips choice outcome. The trendlines show the overall directions of the data.

To evaluate if consumers' own choice had an effect from pre snack choice to post snack intake, we examined the interaction effect time*choice. We found significant interaction effects for Sweet desire ($F = 41.51$, $p < 0.0001$), Salty desire ($F = 17.45$, $p < 0.0001$) and Fullness ($F = 4.39$, $p = 0.038$), meaning that these sensations changed due to consumers' specific snack choice. None of the other variables revealed significant changes due to the snack choice. For a visual representation of some of the time*choice interaction effects, see figure 3. For chips choosers, Salty desire decreased significantly after intake ($p < 0.0001$, $d = 1.0$) and Sweet desire statistically remained the same (non-significant (ns), $p = 0.11$). For chocolate choosers, Salty desire remained statistically the same (ns, $p = 0.83$) and Sweet desire significantly decreased after intake ($p < 0.0001$, $d = 0.9$). Fatty desire and Desire to snack significantly decreased for both chocolate choosers and chips choosers. Table 3 displays the time*choice pair wise comparisons for all included variables with means and standard deviations.

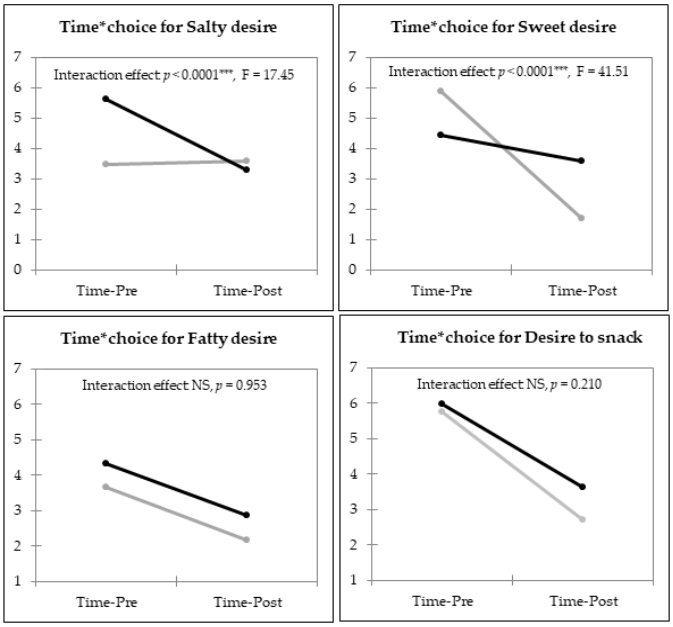

Figure 3: Time*choice interactions visually represented for Salty desire, Sweet desire, Fatty desire and Desire to snack pre snack choice and post snack choice. Black (●) = chips choice, grey (●) = chocolate choice. Variables were evaluated using visual analogue scale (VAS) ranging from 0 to 10. NS = non-significant.

Discussion

Sweet and Salty Desires as Drivers of Snack Choice

One of the key results in this research study showed that the interaction effect between Salty desire and Sweet desire was significant and explanatory for consumers' actual snack choice. This demonstrates that both of these desires depended on each other, e.g. such that consumers who chose chips experienced high Salty desire, but at the same time low Sweet desire and vice versa for chocolate choosers, figure 1. The interaction effect for chocolate choice was positive. This interprets such that an increasing Sweet desire, enlarges Salty desires' negative effect on chocolate choice. Contrary, the interaction effect for chips was negative. This interprets such that an increasing Sweet desire, reduces Salty desire's positive effect on chips choice. Sweet desire and Fatty desire did not show significant effects alone for snack choice. This could indicate that the difference in Salty desire was the more important for snack choice overall, shown in the results where Salty desire had strong effects for both chocolate and chips (positive or negative) (Figures 1 and 2). This might explain why Sweet desire did

Table 3: Time*choice pairwise comparisons including means and standard deviations.

	Pre chocolate choice	Pre chips choice	Post chocolate choice	Post chips choice
Hunger	4.38^{ab} (2.6)	5.19^{a} (2.7)	2.79^{c} (2.4)	3.73^{bc} (2.3)
Fullness	4.55^{b} (2.6)	3.91^{b} (2.5)	6.51^{a} (2.6)	4.83^{b} (2.4)
Desire to snack	5.75^{a} (2.6)	5.97^{a} (2.3)	2.69^{b} (2.7)	3.62^{b} (2.8)
Sweet desire	5.89^{a} (2.6)	4.42^{b} (2.5)	1.68^{c} (2.1)	3.57^{b} (2.7)
Salty desire	3.47^{b} (2.5)	5.63^{a} (2.0)	3.60^{b} (3.1)	3.29^{b} (2.6)
Fatty desire	3.67^{ab} (2.6)	4.33^{a} (2.4)	2.17^{c} (2.4)	2.86^{bc} (2.2)
Energized	4.24^{b} (1.9)	4.26^{b} (1.7)	5.90^{a} (2.1)	5.27^{ab} (1.9)
Concentration	4.45^{a} (2.7)	4.25^{a} (1.7)	4.76^{a} (2.4)	5.22^{a} (1.5)
Sleepiness	4.73^{a} (2.5)	4.74^{a} (2.2)	3.69^{a} (2.3)	4.01^{a} (1.9)

Means with different superscript (^{a,b,c}) within a row differ significantly (Bonferroni $p < 0.05$, critical value = 2.69).

not show any effect alone for the sweet snack, because the difference in Salty desire was more important for snack choice in this study. This perhaps shows that consumers chose chocolate because they did not want chips, hence so not because of a high Sweet desire, but because of a low Salty desire. The inclusion of a 'neither' option in the snack choice options might have accommodated this situation. This is recommended in future studies. Both snacks could resemble a fatty taste profile, perhaps explaining why fatty desire alone did not show significant effect on snack choice.

As such, choice was driven by subjective sensory specific desires (SSD), especially Salty desire, and this resonates with our hypothesis that particularly SSDs would contribute to actual snack choice late afternoon. Similar results were found in another study by Duerlund M, et al. (2020) [16], where especially SSDs proved influential in consumer's real choice between six snack products. Contrary, Olsen A, et al. (2011) [23], found low correlations between SSDs and food choice, involving food choices which were presumed healthy foods such as peach, avocado, grapefruit and nuts [23]. The present study only included presumed unhealthy hedonic palatable snacks being chocolate and chips. Desires for specific sensory stimuli are suggested to be related to hedonic hunger [13,16,31,37]. Hedonic hunger as a concept refers to a subjective state and is driven by a need for pleasure and joy rather than a need for nutrients [12,13]. Hedonic hunger is proposed to function as a new or other dimension of appetite, as opposed to homeostatic hunger, where your physiological state and needs drive food consumption[10,13]. Motivations for snacking is known to comprise numerous factors and include both homeostatic hunger as well as hedonic (non-homeostatic) hunger [1]. According to Bellisle F (2014) [8], snacking affects quality of our diet and energy balance, in two opposing views. Firstly, snacking can function to facilitate and adjust energy intake and food regulation. This snacking often associates to people who snack due to homeostatic hunger at predictable times during the day. Secondly, snacking can also happen in the absence of hunger and in more irregular patterns [8]. Snacking when you are hungry tends to be associated to choose and consumption of healthy foods, whereas snacking in the absence of hunger tends to lead to consumption of high-fat and high-sugar foods [1,8]. In this study, we saw that hedonic hunger drove snack choice, but homeostatic hunger did not. Supporting this, Chapelot D, et al. (2003) [38], found no biological cues before snacking in terms of hunger scores nor insulin or glucose decline, and concluded that snacks were eaten even in the absence of homeostatic needs[1]. Choosing a snack due to your desires suggests a search for the snack to fulfil your specific desire. This resonates with the knowledge we have that snacking can be motivated by the rewarding effect from the snack [1]. In this study we only included presumed palatable hedonic snacks and results suggest that consumers' choice was driven by a reward-seeking behavior, thus a desire for pleasure and reward and satisfying the sensory desire.

It is suggested that one's regulation of intake may depend on the individual's sensitivity to reward cues [1,4,17,22]. However, the connection between sensitivity, reward and snacking habits warrant further investigation. Nonetheless, the present study highlights the importance of hedonic factors such as SSDs in actual snack choice. It is furthermore suggested that our food environment plays a significant role in inducing snacking behavior, with abundant and continuous access to convenient, highly processed foods often high in salt, fat, and sugar [39].

Changes in Sensory Specific Desires Due to Snack Choice

Another key result from this study showed the significant decrease of Salty desire only after chips intake and the significant decrease of Sweet desire only after chocolate intake, demonstrating a time*choice interaction effect for these two SSD variables, figure 3. The consumers thus affected their own desires by their own choice, either deliberately or subconsciously, and thereby satisfied their sensory desire by their choice. Notably, in addition to these results, we saw that Sweet desire remained the same for chips chooser and Salty desire remained the same for chocolate choosers, hereby highlighting the effect choice had on SSDs and that this effect depended on the sensory characteristic of the chosen snack. We thus here see the power of choice of snack to alter desires and to fulfil desires. Olsen A, et al. (2011) [23], also found changes in SSDs from eating a sweet, sour or fatty stimulus, resulting in lower desires for that specific taste. Furthermore, they found that the biggest values in change, and hereby substantiating the effect, were seen for sweet desire pre and post eating a sweet yoghurt[23]. Supporting this, we saw the biggest overall change for Sweet desire when eating chocolate, as compared to the other desire changes and also compared to eating chips. A next level study could include to test if sweet healthy snack options, e.g. a sweet banana, could satisfy and decrease sweet desire to the same extent that the sweet chocolate did, indicating if healthier snack options could meet the same needs and potentially replace the unhealthy options.

Harington K, et al. (2016) [40], found that desire for sweet was maintained for three hours after eating two slices of bread, whereas fatty, savory and salty desire significantly decreased. They hypothesize a so-called dessert-mentality, suggesting that sweet desire is partially detached from appetite, ergo there is always room for something sweet after eating. This suggests a somewhat disconnect of sweet desire from the other desires. In the present study, desire for sweet was maintained for the consumers eating chips, but not for the consumers eating chocolate, suggesting a sweet stimulus snack to alter sweet desire but not at non-sweet stimulus snack. In another study by the authors, both sweet, fatty and salty desire significantly increased in a period of three hours after consumption of a non-flavored yoghurt breakfast meal [32]. Andersen BV, et al. (2017) [28], found that sweet desire increased after intake of soup added cayenne pepper, but decreased after intake of soup with no added cayenne pepper. Sweet stimulus is known to relieve pain from irritants, and thus could explain sweet desire's increase after a spicy meal [28,29]. Above studies mainly refer to consumption of meals, e.g. soup [28,29], yoghurt [32] and bread [40] and together with the present snack results, it is suggested that sweet desire may be induced or remain after consumption of a non-sweet meal/snack. As such, a 'dessert mentality' perhaps mostly apply after the consumption of non-sweet stimulus food. Additional results showed that Fatty desire and Desire to snack significantly decreased for

both chocolate choosers and chips choosers and with no interaction effect from choice. This perhaps indicates that both snacks indeed were perceived as fatty and that both snacks facilitated change in the Desire to snack in general. Furthermore, we saw that Fullness significantly increased with eating chocolate, but not with eating chips. Chocolate, however, also contained more calories than the chips, forecasting a greater physiological fullness.

Monitoring the development of SSDs pre, during and post intake is important for our food choices and intake and can potentially add knowledge about additional calorie intake [22]. Applicability of the current findings include clever meal and snack designs with focus on overall sensory satisfaction, thus sensory quality replacing sensory quantity, in order to avoid or delay development of sensory desires and thereby additional calorie intake [14,28]. It is however important to distinguish meals and snacks when addressing SSD effects. Further snacking investigation should include both behavioral components as well as product components [8] and future perspectives should build on the connections between snacking, SSD development and appetite. Implications of snacking on health, e.g. risk of weight gain and appetite control, calls for larger and more long-term snacking studies [4].

Limitations

The sample size used for this study mainly consisted of female participants, which could have influenced the snack choice outcomes. Women in general tend to choose healthier snacks than men and factors for this include health consciousness and self-control [6,16,18,21]. However, both snacks in this study were selected and assumed to belong to an unhealthy pleasurable snack category, attempting to avoid any bias related to gender or health-conscious factors. A further limitation includes the possibility that consumers' choice was biased from their own rating, meaning they felt they should choose a certain snack due to their rating. In this aspect, consumers' ratings post snack intake could also be biased so that consumers' ratings of SSDs could be based on the specific snack they just consumed, and as such could reflect sensory specific satiety (SSS) for the specific snack rather than general SSDs. This is unknown. This could have been accommodated to a certain extent by including further desire measures e.g. desire for specific foods/snacks to be able to conclude on SSS vs SSDs. However, by further dissecting a subjective desire, we also risk consumers to become too analytical about their evaluations and about their snack choice.

Moreover, the snacks were not iso-caloric, but instead chosen to be visually comparable to avoid portion size biases. Nonetheless, this could be a biased factor in the interpretation of the effects from eating the snacks. Furthermore, this study focused on the snack choice between only two types snack products (chocolate or chips) in a forced choice setting. This of course do not resemble a natural setting with perhaps more and different choices and this can have affected the choice outcomes, e.g. such that consumers who chose M&Ms only did so because they did not want the chips option. Although inclusion criteria involved a willingness to eat a snack as art of the study, the adding of a 'neither' option might have reduced this possible bias, also highlighted in section 4.1.The generalizability of the results is unknown and more studies are needed to say something about e.g. overweight people or different age groups.

Conclusions

This research study aimed to investigate the relationship between sensory specific desires (SSD) and actual snack choice. It was hypothesized that specific appetite sensations would contribute to actual snack choice in the late afternoon, with particularly SSDs showing the greatest effects at this time. Results revealed the interaction between Salty desire and Sweet desire to be a significant driver of snack choice, supporting the hypothesis, but no significant effect of Fatty desire was found to influence snack choice. It was further hypothesized that actual snack choice and intake would alter SSDs such that the choice would reduce and fulfil the specific sensory desire from pre choice to post choice. Findings showed that actual snack choice significantly affected SSDs and that this effect depended on the sensory characteristic of the chosen snack, thus confirming the hypothesis. The present study adds to the knowledge about how SSDs affect and are affected by actual snack choice. It is concluded that SSDs are important drivers of actual snack choice and that snack choices having the desired sensory characteristics can satisfy these desires upon consumption. Therefore, including desires when studying choice behavior is highly relevant and provides valuable knowledge. These findings provide further insights into eating behaviors, specifically as to how and why we choose snacks and the role that SSDs play in snacking behavior.

Acknowledgements

We would like to thank Polymeros Chrysochou and Tobias Otterbring for contact to Aarhus BSS bachelor students. We would also like to thank Kamilla Hall Kragelund and Signe Lund Mathiesen for practical help with conducting of the study.

Funding

This work was supported by the 'Food and Health Research Theme' at the Sino Danish Center, Aarhus, Denmark and the Aarhus University Graduate School of Science and Technology, Aarhus, Denmark. The work is also linked to the 'Appetite and Satiety' research space at the research team Food Quality Perception and Society at Department of Food Science, Aarhus University.

Authors' Contribution

Study conceptions and design: M Duerlund, BV Andersen, DV Byrne.

Acquisition of data: M Duerlund.

Analysis and interpretation of data: M Duerlund, BV Andersen.

Drafting of manuscript: M Duerlund.

Critical revision: M Duerlund, BV Andersen, DV Byrne.

All authors have approved the final article.

Conflicts of Interest

The authors declare no conflict of interest.

References

1. Hess JM, Jonnalagadda SS, Slavin JL (2016) What is a snack, why do we snack, and how can we choose better snacks? a review of the definitions of snacking, motivations to snack, contributions to dietary intake, and recommendations for improvement. Adv Nutr 7: 466-475.https://doi.org/10.3945/an.115.009571
2. Köster EP (2009) Diversity in the determinants of food choice: a psychological perspective. Food Qual Prefer 20: 70-82.https://doi.org/10.1016/j.foodqual.2007.11.002
3. Leng G, Adan RA, Belot M, Brunstrom JM, de Graaf K, et al. (2017) The determinants of food choice. Proc Nutr Soc 76: 316-327.https://doi.org/10.1017/S002966511600286X
4. Njike VY, Smith TM, Shuval O, Shuval K, Edshteyn I, et al. (2016) Snack food, satiety, and weight. Adv Nutr 7: 866-878.https://doi.org/10.3945/an.115.009340

5. Duffey KJ, Popkin BM(2011) Energy density, portion size, and eating occasions: contributions to increased energy intake in the United States, 1977-2006. PLOS Med 8: e1001050.https://doi.org/10.1371/journal.pmed.1001050

6. Hartmann C, Siegrist M, van der Horst K (2013) Snack frequency: associations with healthy and unhealthy food choices. Public Health Nutr 16: 1487-1496.https://doi.org/10.1017/S1368980012003771

7. Mattes RD (2018) Snacking: A cause for concern. PhysiolBehav 193: 279-283.https://doi.org/10.1016/j.physbeh.2018.02.010

8. Bellisle F (2014) Meals and snacking, diet quality and energy balance. Physiol Behav 134: 38-43.https://doi.org/10.1016/j.physbeh.2014.03.010

9. Rogers PJ, Blundell JE (1990) Psychobiological bases of food choice. BNF Nutr Bull 15: 31-40.

10. MacFie H, editor (2007) Consumer-led food product development. Woodhead Publishing, Boca Raton, Unites States.https://doi.org/10.1533/9781845693381.1.81

11. Dalton M, Finlayson G(2014) Psychobiological examination of liking and wanting for fat and sweet taste in trait binge eating females. Physiol Behav 136: 128-134.https://doi.org/10.1016/j.physbeh.2014.03.019

12. Liu CM, Kanoski SE(2018) Homeostatic and non-homeostatic controls of feeding behavior: distinct vs. common neural systems. Physiol Behav 193: 223-231.https://doi.org/10.1016/j.physbeh.2018.02.011

13. Lowe MR, Butryn ML(2007) Hedonic hunger: A new dimension of appetite?. Physiol Behav 91: 432-439.https://doi.org/10.1016/j.physbeh.2007.04.006

14. Møller P (2015) Satisfaction, satiation and food behaviour. Curr Opin Food Sci 3: 59-64.https://doi.org/10.1016/j.cofs.2015.02.008

15. Yeomans MR, Blundell JE, Leshem M(2004) Palatability: Response to nutritional need or need-free stimulation of appetite?. Br J Nutr 92: S3-S14.https://doi.org/10.1079/bjn20041134

16. Duerlund M, Andersen BV, Alexi N, Peng M, Byrne DV (2020) Subjective sensations related to food as determinants of snack choice. Foods 9: 336.https://doi.org/10.3390/foods9030336

17. Recio-Román A, Recio-Menéndez M, Román-González MV (2020) Food reward and food choice. An inquiry through the liking and wanting model. Nutrients 12: 639. https://doi.org/10.3390/nu12030639

18. Honkanen P, Olsen SO, Verplanken B, Tuu HH (2012) Reflective and impulsive influences on unhealthy snacking. the moderating effects of food related self-control. Appetite 58: 616-622.https://doi.org/10.1016/j.appet.2011.11.019

19. Kahneman D (2011) Thinking, Fast and Slow. Macmillan, United States.

20. Wansink B, Sobal J (2007) Mindless eating: The 200 daily food decisions we overlook. Environ Behav 39: 106-123.https://doi.org/10.1177/0013916506295573

21. Weijzen PL, de Graaf C, Dijksterhuis GB (2009) Predictors of the consistency between healthy snack choice intentions and actual behaviour. Food Qual Prefer 20: 110-119. https://doi.org/10.1016/j.foodqual.2007.05.007

22. Mela DJ (2006) Eating for pleasure or just wanting to eat? Reconsidering sensory hedonic responses as a driver of obesity. Appetite 47: 10-17.https://doi.org/10.1016/j.appet.2006.02.006

23. Olsen A, Ritz C, Hartvig DL, Møller P(2011) Comparison of sensory specific satiety and sensory specific desires to eat in children and adults. Appetite 57: 6-13.https://doi.org/10.1016/j.appet.2011.03.009

24. Havermans RC, Janssen T, Giesen JC, Roefs A, Jansen A (2009) Food liking, food wanting, and sensory-specific satiety. Appetite 52: 222-225.https://doi.org/10.1016/j.appet.2008.09.020

25. Hetherington M, Rolls BJ, Burley VJ(1989) The time course of sensory-specific satiety. Appetite12: 57-68.https://doi.org/10.1016/0195-6663(89)90068-8

26. Rolls BJ (1986) Sensory-specific satiety. Nutr Rev 44: 93-101.https://doi.org/10.1111/j.1753-4887.1986.tb07593.x

27. Rolls BJ, Rolls ET, Rowe EA, Sweeney K (1981) Sensory specific satiety in man. Physiol Behav 27: 137-142.https://doi.org/10.1016/0031-9384(81)90310-3

28. Andersen BV, Byrne DV, Bredie WL, Møller P (2017) Cayenne pepper in a meal: Effect of oral heat on feelings of appetite, sensory specific desires and well-being. Food Qual Prefer 60: 1-8.https://doi.org/10.1016/j.foodqual.2017.03.007

29. Reinbach HC, Martinussen T, Møller P (2010) Effects of hot spices on energy intake, appetite and sensory specific desires in humans. Food Qual Prefer 21: 655-661.https://doi.org/10.1016/j.foodqual.2010.04.003

30. Act on research ethics review of health research projects. Denmark.

31. Duerlund M, Andersen BV, Grønbeck MS, Byrne DV (2019) Consumer reflections on post-ingestive sensations. A qualitative approach by means of focus group interviews. Appetite 142: 104350.https://doi.org/10.1016/j.appet.2019.104350

32. Duerlund M, Vad Andersen B, Victor Byrne D (2019) Dynamic changes in post-ingestive sensations after consumption of a breakfast meal high in protein or carbohydrate. Foods 8: 413.https://doi.org/10.3390/foods8090413

33. Flint A, Raben A, Blundell JE, Astrup A (2000) Reproducibility, power and validity of visual analogue scales in assessment of appetite sensations in single test meal studies. Int J Obes 24: 38-48.https://doi.org/10.1038/sj.ijo.0801083

34. Cohen J (1988) Statistical power analysis for the behavioral sciences.(2nd edtn.), Lawrence Erlbaum Associates, New York, United States.https://doi.org/10.4324/9780203771587

35. Harrell Jr FE (2015) Regression modeling strategies: with applications to linear models, logistic and ordinal regression, and survival analysis.(2nd edtn.), Springer Cham,Switzerland.https://doi.org/10.1007/978-3-319-19425-7

36. Addinsoft A (2019) XLSTAT statistical and data analysis solution. New York, United States.

37. Murray M, Vickers Z (2009) Consumer views of hunger and fullness. A qualitative approach. Appetite 53: 174-182.https://doi.org/10.1016/j.appet.2009.06.003

38. Chapelot D, Marmonier C, Aubert R, Gausseres N, Louis-Sylvestre J (2003) A role for glucose and insulin preprandial profiles to differentiate meals and snacks. Physiol Behav 80: 721-731.https://doi.org/10.1016/j.physbeh.2003.12.006

39. Hall KD (2018) Did the food environment cause the obesity epidemic?. Obesity 26: 11-13.https://doi.org/10.1002/oby.22073

40. Harington K, Smeele R, Van Loon F, Yuan J, Haszard JJ, et al. (2016) Desire for sweet taste unchanged after eating: evidence of a dessert mentality?. J Am Coll Nutr 35: 581-586.https://doi.org/10.1080/07315724.2015.1117956