Using a Visual Cue as Intervention Did Not Reduce the Portion-Size Effect

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**Abstract**

Increased portion sizes leads to increased energy intake, which is associated with obesity. This study examined whether a visual cue as food presentation reduced this portion-size effect. In a 2 by 2 between subject design, 125 participants (84 females, 41 males) were tested to examine the effects of portion size (±40g or ±80g of nachos) and the visual cue of presentation style (in a bowl or circular on a plate). Participants were matched on sex to one of the four conditions: SmallBowl, SmallPlate, LargeBowl, LargePlate. During the test they watched an episode of friends to covertly expose them to the experiment. Results showed a significant effect of portion size (*F*(1, 114) = 18.75, *p* = .000) and no effect of presentation and interaction was found (*F*(1, 114) = .12, *p* = .73 and *F*(1, 114) = 1.24, *p* = .27), respectively). These effects remained significant and insignificant after introducing the covariates hunger and likability of the nachos to the model. On average 53% more nachos were consumed in the large conditions compared to the small conditions. In line with previous research the portion size effect was confirmed in this research. However the intervention of the visual cue had no effect. This suggests that the portion-size effect is strong and future research should address other interventions (for example dividers or colors) to reduce it, to help the prevention and treatment of obesity.

*Keywords:* portion size, visual cues, energy intake, food presentation, obesity

**Introduction**

Obesity has grown to be a worldwide problem and nowadays this phenomenon is better known as the obesity epidemic (Herman & Polivy, 2008). By definition obesity is a Body Mass Index (BMI) equal to, or greater than 30. BMI is an index which is calculated by the weight of a person in kilograms, divided by the square of his height in meters (World Health Organization, 2015). According to the World Health Organization (2015) the prevalence of obesity worldwide has more than doubled over the past 35 years. In 2013-2014, the percentage of obesity among adults (age 19+) in the Unites States was 37.9% in comparison to 22.3% in 1988-1994 (Centers for Disease Control and prevention, 2016). In the Netherlands the percentage of obesity among adults (age 19+) was 13.7% in 2015 in comparison to 5% in 1981 (Volksgezondheid en zorg, 2016a; Volksgezondheid en zorg 2016b). Obesity has been associated with diseases like diabetes, musculoskeletal disorders, cardiovascular diseases and some type of cancers (World Health Organization, 2015).   
 A large part of this problem can be attributed to an increased energy intake, due to enlarged food portion sizes and increased consumption of higher energy density foods (Ledikwe, Ello-Martin & Rolls, 2005; Rolls, 2014; Zlatevska, Dubelaar & Holden, 2014). Over the past decades the food portion size increased: not only 2-5 times larger than the original size in (fast food) restaurants, at least double the standard serving in supermarkets (Young & Nestle, 2003) and a 33.2% increase in home recipes since 1996 (Wansink & Payne, 2009), but even the painting of the last supper showed an 69.2% increase of the main course entree since 1000AD/CE (Wansink & Wansink, 2010). A similar increase in energy intake has been found in the consumption of higher energy dense foods in comparison with lower energy dense foods: a 35.2% calorie density increase since 1939 in 18 classic recipes (Wansink & Payne, 2009) and Bell, Castellanos, Pelkman, Thorwart and Rolls (1998) found a mean difference of 424 kcal more energy consumption in the high density condition relative to the low density condition. A study of Rolls and colleagues (1999) shows a 16% decrease in the consumption of side dishes if the subjects ate a low energy dense main dish in comparison to a high energy dense main dish. Not only portion size and energy density independently affect energy intake, but according to the review of Kral and Rolls (2004) when both factors are increased within the same meal, their independent effects add up which lead to heightened energy intake.

Food portion size affects energy intake in a way that people consume more if presented with a large portion in comparison to a small portion. This phenomenon is called “the portion-size effect”, whereby changes in the presented food portion size affect the overall food intake (Benton, 2015; Burger, Fisher & Johnson, 2011; English, Lasschuijt & Keller, 2015; Marchiori, Papies & Klein, 2014; Herman, Polivy, Pliner & Vartanian, 2015). A recent meta-analytic review of Zlatevska and colleagues (2014) found an average consumption increase of 35% when the portion size was doubled. Another study of Kerameas, Vartanian and Herman (2015) found that participants consumed 70% more in the large portion in comparison with the small portion. The most prevalent normative mechanism to explain the portion-size effect is that people assume that the given food portion is the appropriate amount to eat (Herman et al., 2015). Therefore portion size is used as an indicator to determine how much to eat. Subsequently, if the portion size is bigger, consumption increases.   
 Visual cues play an important role in eating behavior because -besides scent- the first contact with food is through the eyes (Wadhera & Capaldi-Phillips, 2014). Visual cues such as: proximity, visibility, color, variety, height, shape, surface area, portion size and number, can affect the appearance and palatability of food, which in turn can lead to increased or decreased energy intake (Wadhera & Capaldi-Phillips, 2014). It is suggested that visual cues are a part of the determination process on how much to eat (Herman et al., 2015). A study of Wansink, Painter and North (2005) shows people considerably rely on visual cues to determine the appropriate amount to eat. Their biased visual cue (a self-refilling bowl of soup) lead people to consume 73% more soup relative to the accurate visual cue (a normal bowl). Several studies show that visual cues can be used to limit the energy intake. Kerameas and colleagues (2015) suggest that their research, demonstrate that cutting food in smaller units can help to decrease food intake. In line with the previous study, Geier, Wansink and Rozin (2012) found more than 50% decrease on food consumption, when a red potato chip was placed at different fixed intervals in the chips-tube. Wansink and Payne (2007) and Kennedey-Hagan and colleagues (2011) found that food leftovers -like bones and shells- can be used to establish how much food is consumed, resulting in a decrease of food consumption. In all these studies visual cues helped people to recognize the appropriate amount of food. Although a study of Burger and colleagues (2011) did not find an impact on the portion-size effect of visual cues in a blindfolded versus visible conditions, these findings suggest that the exact role of visual cues in the portion-size effect are indistinct, but it may play an important one.   
 Visibility as a visual cue can promote food consumption, for example more sandwiches were eaten in transparent packages than opaque packages (Wadhera & Capaldi-Phillips, 2014). On the other hand it can reduce food consumption by showing how much food has been eaten (as seen in the studies of Wansink and Payne (2007) and Kennedey-Hagan and colleagues (2011)). Along these lines using empty wrappers of candy as visual cue, similar findings could be expected. However, not all food leave something tangible to be seen. This research focusses on visibility as visual cue, in an effort to reduce energy intake in high density foods: such as nachos. To identify how much is consumed with food that do not leave anything behind, we propose that when it is presented in a structured placed way on a plate instead of in a bowl, people will be more aware of how much they eat. We suggest that the gap, which arises when food is eaten, can function as an visual marker to help determine the appropriate portion to eat. We expect that it will affect food intake in a similar way as food residuals and subsequently less calories will be consumed. We will not only focus on reduced intake by structured presentation, but also combine it with the portion-size effect. This strong effect is related to visual cues, as described in the literature. As visual cues can influence the energy intake, we look at the structured presentation as an intervention to reduce the portion-size effect. The following hypotheses are made: 1. More snacks will be consumed in the large portion bowl compared to the small portion bowl, because of the portion size effect. 2. Less snacks are consumed when it is presented in a structured placed way instead of in a bowl. 3. The amount of snacks consumed in the structured placed presentation will be similar for the large and small portion. Finding an intervention that affects the portion-size effect or decreases food consumption, is important in the prevention of overeating in this supersize economy where obesity is increasingly present.

**Method***Participants*   
 In total 125 (84 females, 41 males) students participate in this research. They were contacted by: face to face recruitment in and around the campus of Utrecht University, people responded to the poster by sending an email, or visited the laboratories. They received €4,- or 1 course credit in exchange for their participation. Exclusion criteria were people who could not understand or read Dutch. Data from participants who did not like the nachos (2 or less on a 7-point Likert scale) were excluded in the analyses (N = 7).

*Design* This study used a 2 (portion size: small vs. large) by 2 (presentation: bowl vs. plate) between subjects design. The nachos (which had a triangular shape) and chili-dip sauce were bought at the local Aldi supermarket. The small portion consisted of 20 nachos and the large portion consisted of 40 nachos, which respectively corresponded to ±40 and ±80 grams. The large portion was determined by doubling the small portion size, which is similar to the research of Burger and colleagues (2011). Accordingly to the nachos, the chili-dip sauce was available in two sizes: small (85 grams) and large (160 grams). Participants in the bowl condition were presented a white small/large bowl and a transparent small/large bowl with chili-dip sauce next to it. Participants in the plate condition were presented a white small/large plate, with a transparent small/large bowl chili-dip sauce placed at the center on the plate. The ratio between empty bowl/plate space and snacks were kept similar in all conditions to avoid influence of the Delboeuf illusion on the results. This illusion can apply to food, and it states that the perceived size of food can be biased by the magnitude of the plate it is served on (McClain et al., 2014; Van Ittersum & Wansink, 2012). It was calculated that 90 participants were needed to achieve power of .80 (with alpha .05 and a medium effect size of .30).

Internal consistency reliability of different subdomains of the questionnaire were tested by multiple Cronbach's alpha’s. If the Cronbach's alpha was ≥ .70 the items were merged together. An univariate Analysis of Variance (ANOVA) was conducted including all hypothesized covariates to explore their effect on the experiment, when *p* > .05, it was removed from the model. Portion size (small/large) and presentation (bowl/plate) were independent variables and amount of consumed nachos in grams was the dependent variable. Alpha was set at .05. Potential confounders were hunger, mood, likability of the nachos, BMI, health goals and start time of experiment. A main ANOVA was conducted with the same (in)dependent variables as above to explore the effect of the experiment on energy intake. In addition discovered confounders were included as covariates in another ANOVA. Then a similar post hoc ANOVA with covariates was conducted on a sample without participants who ate everything or nothing, to explore if this skewed the data. It is possible that the results are influenced by the arbitrary chosen sizes of the small and large portion and the fact that participants did not have the possibility to eat more nachos than the provided portion.

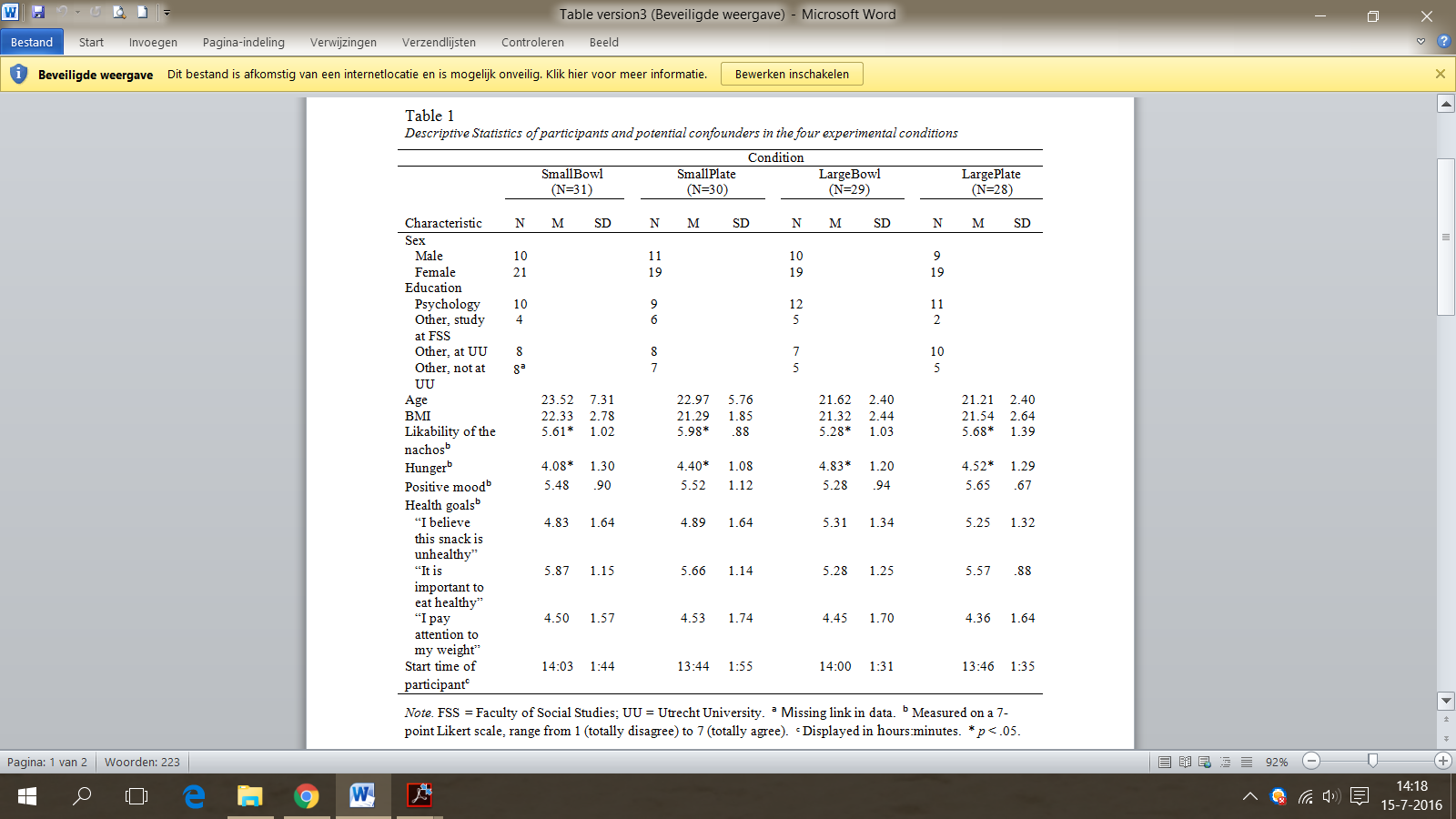
*Procedure* The experiments were conducted in individual laboratory’s cubicles, which contained a desk with computer, headset, questionnaires and a chair besides the snacks. The experiments were executed between 11.00 and 17.30 hour from Monday till Friday, for three consecutive weeks. In all conditions, the snacks were placed at the left side of the desk next to the computer. The snacks were present from the start of the experiment and had been counted and weighted by the researcher in advance. Participants were matched by gender to one of the four conditions upon arrival and placed in a cubicle by the researcher. Before written informed consent was obtained from all participants, they read the cover story to conceal the true nature of the study: “This study tries to identify the influence of TV series genres on snack taste perception.” After signing, participants were told that they could eat as much as they want from the nachos and the researcher left the cubicle. The questionnaire contained step by step instructions for the participants to follow during the entire experiment. At the start of the experiment participants filled out the first part of the questionnaire which contained questions about mood, hunger and some personal information. Then all participants watched the same 22.44 minute long episode of “Friends” (S02E12) to covertly expose them to the experiment. After watching the video, participants filled out the remaining questions about likability of the video, snacks, health and personal information like height and weight. This latter was intentionally done to prevent suspicion among participants during the experiment. No participant guessed the true purpose of the study. When participants finished the last questionnaire, they were debriefed by letter about the true nature of the study and they received €4,- or 1 course credit. After participants had left the cubicle, the researcher counted and weighted the remaining amount of nachos and weighted the chili-dip sauce.

*Measures*  
 *Demographics.* Demographic information such as gender, age, weight and height (used to calculate BMI) and education level were obtained.

*Mood and hunger level.* Participants were asked to indicate their mood (degree of happy/down and relaxation) and their level of hunger/satiety by statements on a 7-point Likert scale, range from 1 (totally disagree) to 7 (totally agree). The two hunger questions had an inter-item reliability, Cronbach’s alpha = .71 and the three mood questions had an inter-item reliability of Cronbach’s alpha =.76. Mood and hunger may influence the amount of nachos participants eat during the experiment, therefore they were analyzed as potential covariates in the data analysis.

*Likability of the video and snacks*. A 6-item questionnaire about the likability and knowledge of the video was included to back up the cover story. Three likability items of the video had an inter-item reliability with a Cronbach’s alpha = .84. Participants also filled out an 11-item questionnaire about the likability of the snack that partially consist of bogus questions to back up the cover story. The majority of the questions were measured by statements on a 7-point Likert scale from 1 (totally disagree) to 7 (totally agree). Questions about if participants liked the snacks were important to include, because it might affect the overall energy intake. They were analyzed as potential covariates in the data analysis or excluded in the sample.

*Health and dieting.* Three questions about health goals were added to control for possible confounding influence on the results. Therefore they were analyzed as potential covariates in the data analysis. These questions were formulated as statements and were measured on a 7-point Likert scale from 1 (totally disagree) to 7 (totally agree).

**Results** *Participants* By excluding participants who did not like the nachos (2 or less on a 7-point Likert scale), the remaining sample consisted of 118 participants (seventy-eight (66.1%) females and forty males (33.9%)). The average age of the participants was 22.36 (*SD* = 5.01) and their mean BMI was 21.6 kg/m² (*SD* = 2.5). Most participants (35.6%) studied psychology. Table 1 shows participant characteristics with potential confounders divided by condition.

*Nachos intake*

An univariate ANOVA was conducted including all hypothesized covariates, only hunger and likability of the nachos differed significantly between the four conditions (respectively *F*(1, 101) = 15.75, *p* = .000 and *F*(1, 101) = 12.24, *p* = .001), therefore they were treated as covariates in the analyses. The variables age, education, mood, sex, BMI, health goals and start time of the experiment did not differed significantly between the conditions, all *p*’s > .19, indicating a successful randomization.

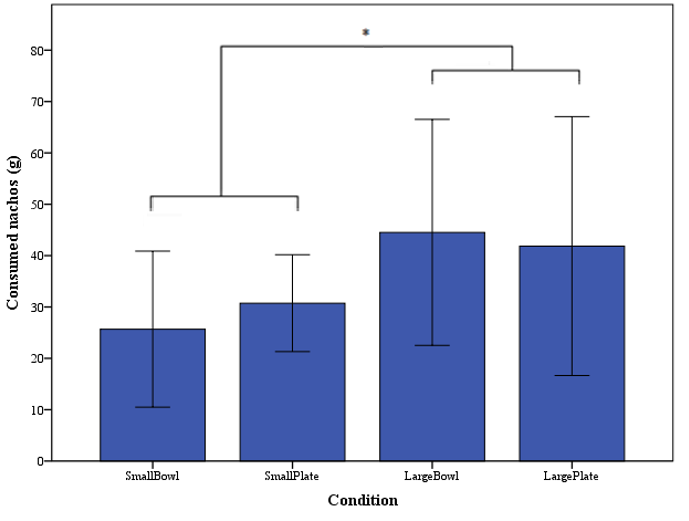
 A main univariate ANOVA was conducted without covariates, a significant effect of portion size was found (*F*(1, 114) = 18.75, *p* = .000) and no effects of presentation (*F*(1, 114) = .12, *p* = .73) or interaction (*F*(1, 114) = 1.24, *p* = .27). These results persisted, even after correction for the two covariates (portion size *F*(1, 112) = 20.67, *p* = .000; presentation *F*(1, 112) = .06, *p* = .81; interaction *F*(1, 112) = .53, *p* = .47). On average participants consumed 53% more nachos in the large conditions (M = 43.21, SD = 23.45) compared to the small conditions (M = 28.16, SD = 12.84). Table 1 is a graphical representation of the amount of nachos consumed by condition.

Figure 1. Mean and error bars: ± 1 SD of consumed nachos by experimental condition. \* *p* < .001. Significant higher energy intake in large group conditions than small group conditions. Although small and insignificant, there seems to be a smaller difference in mean consumed nachos in the plate condition between the small and large portion size relative to the bowl conditions.

An univariate ANOVA was performed on the sample without participants who ate everything or nothing. This sample consisted of 79 participants (57 females, 22 males). The analyses had similar outcomes: without covariates the main effect of portion size was significant (*F*(1, 75) = 22.25, *p* =.00), when hunger and likability of nachos were added as covariates the effect of portion size remained significant (*F*(1, 73) = 26.44, *p* < .001). No effects for presentation and interaction were significant in both analyses (with or without covariates), all *p*’s > .26.

**Discussion**  
 The aim of this study was to investigate the portion-size effect as well as the importance of visual cues in eating behavior. In line with the literature, our experiment confirmed the portion-size effect (Burger et al., 2011; Diliberti, Bordi, Conklin, Roe, & Rolls 2004; Rolls, Morris & Roe, 2002; Zlatevska et al., 2014). A significant effect was found that indicated participants ate more nachos in the large conditions relative to the small conditions, respectively 53% more nachos were consumed. However our results are contradictory to the hypotheses stating that less snacks are consumed when presented in a structured placed way and the amount of snacks consumed in the structured placed presentation will be similar for the large and small portion. No effects of presentation and interaction were significant, which shows that visual cues did not affect the amount of nachos consumed.

Our results showing a 53% consumption increase in the large portion, which is higher compared to: 43% increased intake of pasta entrée (Diliberti et al., 2004), 26% and 40% increased consumption of pasta entrée in normal and overweight individuals (Burger et al., 2011), 30% increase intake of macaroni and cheese (Rolls et al., 2002), 35% average energy increase in a meta-analytic review (Zlatevska and colleagues, 2014) and lower compared to the study of Wansink and colleagues (2005) who found a 73% consumption increase of soup. The fact that we used snack food as nachos instead of lunch dishes like pasta, may have influenced the consumption. It is possible that people feel faster satiated when eating pasta than nachos.

The importance of visual cues in eating behavior has been suggested by Herman and colleagues (2015), Kerameas and colleagues (2015), Wadhera and Capaldi-Phillips (2014) and Wansink and colleagues (2005). People can rely on visual cues to determine the appropriate amount to eat, subsequently the studies of Wansink and Payne (2007) and Kennedey-Hagan and colleagues (2011) showed that food-leftovers can be an useful cue for people in this process. We proposed that a structured way of food presentation, especially the gap that was created when eating nachos, could be used as a visual cue to determine how much participants already ate. Therefore the gap could be used as an indicator of the appropriate amount. However our results do not support the suggestion that visual cues can be used as a method to suppress intake (Wansink et al., 2005). Even when all participants who did not ate anything or who ate everything, to correct for the ceiling effect because there was no possibility for a refill, presentation and interaction of portion size and presentation remained insignificant. This indicate the same: there is no relationship between structured way of presenting the nachos, energy intake and the portion-size effect.

One possibility to explain the difference in the outcomes and expected outcomes is that the exposure to the experiment was too short. In several studies the exposure time to food was till half time of the Super Bowl, 8 hours or 40-60 minutes (Geier et al., 2012; Kennedey-Hagan et al., 2011; Wansink & Payne, 2007). On the other hand in de study of Wansink and colleagues (2005), participants could eat soup for 20 minutes, which is comparable to the present study.

In addition this study was performed in a laboratory’s cubicle, which is not a natural eating setting, therefore this could have affected the results. In line with this Burger and colleagues (2011), where participants ate in the Children’s Eating Lab of the University, find that the portion-size effect was not attenuated by removing the visual cue. In a more natural eating setting on work during leisure or in a sports bar, studies of Wansink and Payne (2007) and Kennedey-Hagan and colleagues (2011) showed significant results of decreased energy intake in leftover food conditions. Contradictory is the research of Geier and colleagues (2012), their experiment was executed during a lecture and they found significant results of the red chip dividers.

It is also possible that no effect of presentation was found because the episode of Friends participants watched was too distracting and therefore they did not pay much attention to the nachos. In comparison with the study of Wansink and Payne (2007), participants watched the Super Bowl on big screens. Their findings showed a decrease in energy intake in de food leftover condition. Another study showed similar decrease in energy consumption by divider chips while watching a 1 hour or 25 minutes long movie (Geier et al., 2012). Continuing this distraction possibility, watching TV may influence the energy intake. Ogden and colleagues (2013) and Higgs and Woodward (2009) indeed found that watching TV while eating increased energy intake, but as Mathur and Stevenson (2015) state, not all research share these findings uniformly.

Another explanation is that the time of the experiment, ranging from 11.00 till 17.30h, effected the outcomes because it is imaginable that people would not like to eat nachos in the morning or at lunch time. It is difficult to compare the window of time of this research with other research of Geier and colleagues (2012), Kennedey-Hagan and colleagues (2011), Wansink and colleagues (2005) and Wansink and Payne (2007), because some were at lunchtime or in the evening, but did not consist of snack food this study used. Only the research of Geier and colleagues (2012) who also contained chips, was presumably performed during the day. Unfortunately they did not describe the time of the day.

A limitation of the research is that the sample size may not be large enough to find an interaction effect of portion size effect and visual cue. Although preliminary sample power was calculated to find a medium effect size. Another limitation is that the generalization of the results must be done cautiously, because of the homogeneity of the sample, namely students with a healthy BMI (21.63 ± 2.46 kg/m²). It is possible that children or elderly people react differently to the intervention. Last this study focused solely on snack food as nachos, this is one specific food type that has a high density nature but is likely not a part of daily consumption.

Strengths of this research are that the sample consisted of males and females, their ratio was roughly 1:3. In addition the four conditions were equal for age, BMI, sex, mood and health goals, indicating good randomization. Lastly this experiment covered a field of research where a lot needs to be discovered. Limited research exists on visual cues and their influence on energy intake or even on the portion-size effect. This study tried to combine the two research areas of the portion-size effect and visual cues. Although the visual cue did not significantly reduced the amount of nachos eaten, research for better visual paradigms should continue in order to reduce overeating.

Future research should continue to seek for interventions to decrease energy intake and counter the portion size effect. It is important to recognize an appropriate portion to eat when food portion sizes and consumption of high density foods in our environment are increasing, just like the growing numbers of people with obesity. Visual cues can still play a role in decreasing energy intake, because their effects and boundaries are yet to be discovered. These visual cues are interesting to look at because they include a great variety of factors, but this makes it challenging as well. One possibility for future research is to examine bowls or plates with built in dividers; one portion becomes three, therefore people may notice sooner how much they eat from a portion. Another possibility is varying the color of the serving dishes. Color can affect taste perception and energy intake (Piqueras-Fiszman & Spence, 2014), maybe it will affect portion size as well.

In conclusion the portion-size effect was confirmed in this study but the expected effect of the gap as visual cue to reduce the portion-size effect was not found. This study illustrates the difficulty to reduce the portion-size effect. It is clear that more work needs to be done to understand the role of visual cues on eating behavior and the portion-size effect. Future research should address other use of these visual cues, like dividers or different colors utensils. It is important to continue research in this area to suppress overeating and obesity.

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