Can Visual Cues to Portion Size Reduce the Number of Portions of Consumed? Two Randomized Controlled Trials

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Funding :- This research was funded as part of the Department of Health and the ESRI's Research Programme in Healthcare Reform.

Acknowledgements :- We thank the Department of Health for funding and various of its staff for their assistance in devising this study. We are also very thankful to Martina Barjaková, Cameron Belton, Laura Gormley, Hannah Julienne, Shane Timmons and Brian Barry for their time and effort in carefully and laboriously sticking hundreds of labels on to packets of food.

Abstract

Background

Since 1950 the portion size of many snack foods has more than doubled and obesity rates have tripled. Portion size determines energy intake, often unwittingly.

Purpose

This paper tests whether salient visual cues to portion size on packaging of high fat, sugar, or salty (HFSS) snacks can reduce consumption.

Methods

Two pre-registered randomized controlled trials (N = 253 and N = 674) measured consumption in a lab and the home environment. Cues were salient, labelled stripes that demarcated single portions. Participants were randomized to cue condition or control. Consumption was measured without awareness.

Results

The main pre-registered effect of the visual cue was not statistically significant. There was some variation by subgroup. In Study 1, men were more likely to eat the whole can of potato chips than women, but significantly reduced consumption when visual cues were on the pack. The effect size was large: the number of men eating more than the recommended portion fell by 33%. Study 2 monitored household consumption of chocolate biscuits (cookies) sent to family homes in giftpacks. Again, the main effect was non-significant but there was significant subgroup variation. When the person receiving the biscuits was female, households were more likely to eat more than the recommended portion per person per day, but less likely when the visual cues were displayed. The gender of the eaters was not known. The effect size was again large: the number of households eating more than the recommended portion fell by 26%. Households with children were also less likely to open packs with the visual cues compared to control packs. Both studies recorded significant increases in the

likelihood of observing serving size information, together with confusion about what it means.

Conclusions

The studies offer some evidence that salient visual cues could play a role in tackling high consumption of unhealthy snacks, but the effects are confined to specific subgroups and warrant further investigation.

Keywords: Obesity; Portion Size; Snack Consumption; Visual Cues; Labelling; HFSS

1. Introduction

Since 1975, global obesity rates have almost tripled [1]. Concurrently, portion sizes of popular snacks have grown, many doubling since 1950 [2]. This paper describes two randomized trials of a labelling intervention designed to make appropriate portion sizes salient. The aim was to test an intervention that, if successful, could help to restrain consumption of high fat, salt, sugar (HFSS) snacks.

1.1 Overview of the Literature

Inflated portions generate two problems. First, people do not perceive portion size reliably. Consumers underestimate the magnitude of an increase in the size of a portion and overestimate mass when food is cut into smaller pieces (e.g. [3, 4]). Second, the more food that is placed in front of people, the more they eat (e.g. [5]). This "portion size effect" (PSE) is substantial and applies broadly. Doubling portion size increases intake by around 35% [6]. The PSE occurs across food types [6] and sociodemographic characteristics (e.g. [7]). It even resists training in techniques to overcome it [8].

Portion sizes may establish new norms or reference points for consumption. In 2015, 22% of UK individuals said they consume bags of potato chips that are typically meant for sharing in one sitting, rising to 40% in individuals aged 16-24 [9]. In the United States, an experimental study offered participants increasingly large bags of potato chips (28, 42, 85, 128 and 170g) over 5 consecutive sessions. Participants increased the amount they consumed at every session. The effect sizes were large. When offered the 42g bag 62% of women and 88% of men ate the entire bag. When the same participants were given a bag over double the size

(85g) 46% of men still consumed the whole bag, as did 15% of women. The portion size effect is more pronounced when people believe that they have been served what most others would consider a normal portion size [10]. Even when told that the size of an initial portion has been randomly selected, individuals who see larger initial portions then deem larger sizes appropriate [11]. Whatever is on the plate or in the packet becomes inherently meaningful [12]. Exposure to a smaller portion size one day, can reduce consumption on a later date [13]. A similar principle may underlie an effect known as the 'segmentation bias', whereby people eat less when food is divided into smaller units [14]. In short, how much people eat depends on the indicated portion, often unwittingly.

Following a systematic Cochrane review, Hollands et al. (2015) conclude that "policies and practices that successfully reduce, or moderate the effects of, exposure to larger-sized portions, packages, individual units and tableware – in and outside the home – can contribute to meaningful reductions in the quantities of food and non-alcoholic beverages people select and consume in the immediate and short term" ([15] p.49). Yet this is a difficult policy challenge. Pledges by industry may be hard to enforce and undermined by countervailing commercial interests [16, 17]. Some attempts to regulate portion size directly have proved unpopular, including proposed restrictions on soda sizes in New York City. Survey evidence in the US records little support for regulatory restrictions or taxes, with the exception of school-based restrictions or labelling interventions which are more popular [18]. Similar results have been shown in the U.K. and Germany where consumers judged nutritional labelling to be the policy most likely to reduce obesity, with taxes being the least likely [19]. Soft regulatory approaches, such as publication of guidelines, may not be effective, given consumers' lack of attention at key decision-points [20], and difficulty understanding nutritional information on packaging [21, 22] As Just and Payne observed in 2009, food

choice does not often involve high level cognitive input and thus policies that demand such cognitive input from the consumer have not proven to be hugely successful [23]. Policies that rely on heuristics, such as visual cues, may have more promise.

Researchers have tested multiple manipulations of packaging, including shape (e.g. [24, 25]), physical format [26-29], size [30], transparency [31] and plainness [32, 33]. Results are mixed. For instance, partitioning food with physical partitions can allow consumers to exercise greater control [34], but in some cases packaging units of food into multiple smaller packages instead of one large package can lead to higher consumption[35]. This may be because the smaller packages are now perceived as one unit, while the unpackaged units within a larger pack are still seen as individual units. Pictures of portions on packets can alter consumption [36-38], perhaps more so than written information [39]. However, many of these studies tested hypothetical consumption or took place in a lab setting. Consumption may differ between laboratory and natural contexts.

1.2 Current Work and Hypotheses

This last work led us to investigate a more straightforward and perhaps universally applicable adaptation of packaging. Visual cues were printed on packets, in the form of salient stripes that demarcated a portion. The aim was to devise a cue to reduce complexity, make information visually salient, and so provide a reference point to exploit the mechanisms behind the PSE. We are not aware of previous studies that consider a cue of this sort. We tested it via an initial field trial in a specific context (Study 1) and then through a larger study in which consumption of snacks was measured in family homes (Study 2). We pre-registered hypotheses, methods and analysis plan on aspredicted.org (#26986 and #29519). We

hypothesized that printing the visual cue to portion size on packets would reduce consumption of HFSS snacks compared to packets displaying a standard nutritional table.

2. Study 1: Methods

Participants were randomly assigned to receive snacks with or without visual cues to portion size. Consumption was measured, after which the study aims were revealed and participants completed a questionnaire. Data is available on the Open Science Framework.

2.1. Participants

Participants (N = 369) were recruited by a market research company to undertake unrelated studies at two locations for a €30 fee. Half of the sample were men (49%), 56% had a higher education degree, 56% were employed, 42% were under 35, 52% were aged between 35 and 64, 6% were aged 65 and over. They were broadly representative of the local adult populations (one small town, one large city) and were unaware of the study aims.

2.2. Materials

2.2.1. Snacks

The snacks were 40g cans of potato chips, offered in three flavors. An identifier inconspicuously added to the bottom of each can allowed consumption data to be linked to questionnaire responses.

2.2.2. Serving Size Cues

Labelling was designed by the research team and professionally printed by a label manufacturer. In the "cue" condition, the label retained normal branding and information, with the size of some images reduced to accommodate the cues. These consisted of dashed white lines that demarcated a portion and extended around the can along with a double arrow marked "1 serving" (Figure 1). A label reading "2 full servings" was also added at the bottom. In the control condition, packaging was identical but without cues. Serving size information was included in the nutritional table in both conditions.

Figure 1: Potato snack with and without visual cues to portion size

2.2.3. Additional Measures

A computerized questionnaire followed the unrelated study. The first question asked participants to say what they thought the study aims were, to check they had not realized the snack was part of the study. Participants were then told that the experimenters were also interested in what people notice and attend to about serving size information on snack foods.

They were asked whether they had noticed serving size information on their can, and, if so, to provide specifics. They were then asked whether they thought the serving size on a packet was: a health recommendation from the government; a health recommendation from the company; the typical amount eaten according to the government; the typical amount eaten according to the company; or entirely up to the company. They could also choose the option "don't know". Participants were also asked how much they liked the chips on a scale of 1 "Dislike very much" to 5 "Like very much."

2.3. Procedure

Participants arrived in groups of 10 and were randomized by group to the control or cue condition, counterbalanced by time of day. Some 5-10 minutes before the unrelated study began, participants signed in and were offered refreshments, consisting of the snack and a soft drink. A research team member acted as server and asked participants if they would like a snack and, if so, to choose a flavor. Cues were not visible until after this choice was made. Only participants who chose to take a can were included in subsequent analyses. The experiment started 10 minutes after the advertised time, allowing latecomers some time to eat and drink. Participants were then seated at laptop computers and undertook the unrelated study. Participants could continue eating while they completed the unrelated study. After the study aims were revealed, participants were asked to re-consent to use of their data and the experimenter weighed the can.

3. Study 1: Results

Of 369 participants offered snacks, 253 accepted (127 control; 126 cue). There were no significant differences between groups in gender, education, employment status or location. There were slightly fewer people in the category of 65+ in the cue compared to control condition (N=13 vs N=3, χ^2 (2) = 6.71, p = .04). The professional printing was effective; there was no indication that participants thought that the packaging was fake. Just one participant mentioned the snacks when guessing the study aims. Ninety-seven percent of participants gave a rating at or above the midpoint of the scale when asked if they liked the potato chips and 90% gave a rating of "liked somewhat" or "liked very much."

3.1 Consumption

Consumption by cue is shown in Figure 2. Most participants either ate the full can (39.5%) or none of it (38.3%). Mean consumption in the cue condition was 19.9g (SD=18.8), versus 21.3g (SD=18.9) in the control condition. Of those who ate any chips, mean consumption was 32.9 (SD = 12.9) in the control condition and 33.9g (SD = 11.2) in the cue condition. Standard non-parametric Mann-Whitney tests (without clustering) on both sets of continuous data indicated no significant differences between cue and control groups. There was also no apparent difference in the percentage of participants who ate more or less than one portion (20g).

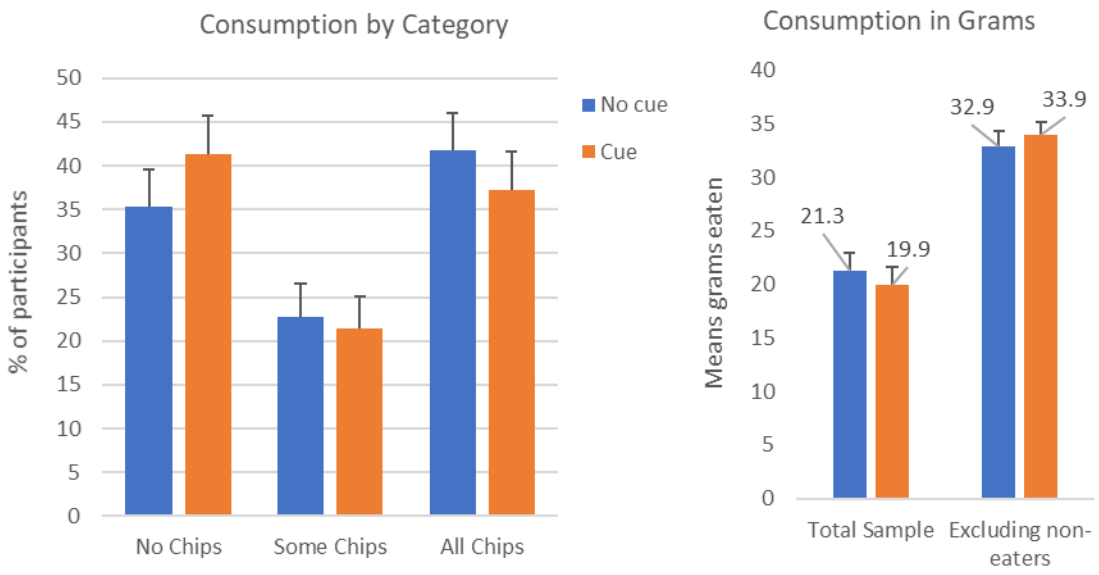

Figure 2: Consumption of potato chips in Study 1

The bounded distribution (see Figures S1 and S2 in Supplementary Material) makes significance testing via standard comparisons of means problematic. Furthermore, because randomization occurred at the group level, adjustment for clustering is needed, as an individual's consumption may have been influenced by the consumption of others around them. We therefore organize the dependent variable into three categories (ate none, ate some, ate all) and deploy ordinal logistic regression with cluster-adjusted standard errors. This method also permits controls for background characteristics and tests for variation by subgroup. Table 1 presents results with beta coefficients and odds ratios. The coefficients indicate the effect of each variable on the likelihood of participants crossing the thresholds from eating no chips to eating some chips to eating all of the chips.

Table 1: Ordinal logistic regressions for level of consumption of potato chips (ate none, ate some, ate all) in Study 1

DV: Ate none (ref.) vs. ate some vs. ate all	(1) B(SE)	OR	(2) B(SE)	OR	(3) B(SE)	OR
Cue	-0.216	.81	-0.164	.85	0.53	1.70
	(0.326)		(0.351)		(0.450)	
Male			0.905**	2.47	1.662***	5.27
			(0.307)		(0.366)	
Cue*Male					-1.467**	.23
					(0.566)	
Degree			.574*	1.77	.516	1.68
			(0.256)		(0.270)	
Working			-0.234	.79	-0.300	.74
			(0.444)		(0.439)	
Age (ref = <35)						
35-64			-0.028	.97	0.045	1.05
			(0.280)		(0.280)	
65+			0.019	1.02	0.253	1.29
			(0.600)		(0.609)	
Obs.	253		241		241	
Groups	34		34		34	

* p < 0.5; ** p < 0.01; *** p < 0.001. DV = dependent variable; Ref. = reference category; B = beta coefficient; SE = standard error; OR = odds ratio.

Model 1 confirms that the overall effect was not statistically significant (p = 0.25, single-tailed). Thus, our primary hypothesis was not confirmed. This is unaffected by introducing control variables in Model 2, which reveals that males and those with higher educational attainment ate more. We tested for interactions between exposure to the cue and each background characteristic. Although we did not hypothesize specific effects, it is possible that the cue was differentially effective across subgroups. Indeed, the data suggest that the cue had an impact on males (p = 0.01, two-tailed). The negative interaction indicates that the effect of the cue was to reduce the likelihood of consuming some or all chips more for men than for women. The interaction is found with the inclusion and non-inclusion of control variables. All models pass the standard Brant test of the proportional odds assumption, which assumes that the effect of each variable is consistent across the multiple category boundaries of the dependent variable. To assist interpretation, Figure 3 displays the interaction. The

visual cue was associated with a small, non-significant increase in the likelihood of consuming all of the chips among females and a substantial decrease among males. Fitting a separate ordinal logistic to only the male data, confirms that the reduction was statistically significant in its own right (β = -0.923, SE = 0.413, p = 0.026, two-tailed).

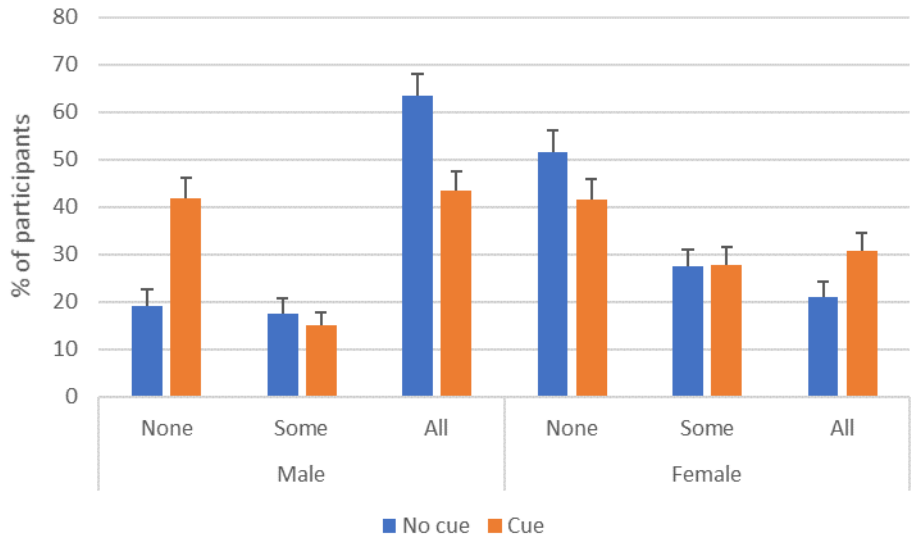

Figure 3: Consumption of potato chips by gender in Study 1

3.2 Noticing

In the whole sample, 41% of participants said that they never seek out portion size information while only 10% said they always do. When asked if they remembered noticing portion size information on the can of snacks, 34.9% of the cue condition reported having observed serving information versus 7.1% in the control condition ($\chi^2(1) = 29.59$, p <.001), with similar proportions by gender. However, there was no difference in the likelihood of consuming some or all of the chips between those who reported noticing or not noticing the cues in the cue condition (β = 0.058, SE = .280, *p* = .84). This may not be surprising given that the portion size effect acts largely outside conscious awareness, and therefore visual cues may act similarly. Additional analyses on the data of participants who did not remember

noticing the cues showed the same effects as in the whole sample and are reported in supplementary material.

3.3 Comprehension of Portion Sizes

Asked what the portion size information meant, participants' responses were close to random: 19% didn't know; 18% believed it was a company health recommendation, 20% a government health recommendation; 19% believed it was the average amount eaten according to the company, 15% according to the government; only 9% said it was entirely up to the manufacturer (the correct answer).

4. Study 1: Discussion

Portion sizes were noticed by substantially more people in the visual cue compared to the control condition, but did not generate a statistically significant reduction in eating overall. Yet they did have an impact on men. Men were more likely to eat some or all of the snack than women, but this was reduced by exposure to the visual cue. Some caution is, of course, required. This was a preregistered study and we did not hypothesize a gender-specific effect. It is a matter of judgement as to how convincing one finds this evidence for the effectiveness of the visual cue. Certainly, it invites further investigation.

One issue with analyzing this data was that most participants ate none or all of the chips. This may be because the 40g size of the can was perceived to be one portion, despite the portion size cues. This is consistent with the strength of the portion size effect. Previous experimental research using potato chips also found that the majority of participants ate all of a 42g pack of potato chips, and men ate more than women [40]. It is also consistent with the idea of completion compulsion and plate cleaners found in other portion size studies [e.g.5, 41, 42]

whereby a proportion of participants will continue eating until a portion is finished or a plate cleared, regardless of the amount of food provided. The 40g size of the can may have induced this distribution and so investigating the cues using a large sharing size packet of food was an aim of Study 2.

Importantly, Study 1 determined that producing professional looking visual cues was feasible and verified their salience. We therefore decided to test the cues in a more ambitious setting on a larger scale. Study 2 employed a package of HFSS food that contained more portions and was consumed in the family home.

5. Study 2: Methods

The design was again a randomized trial. Participants who had completed an unrelated online study were sent giftpacks containing a snack. They were randomized to receive packaging with or without visual cues. A follow-up survey undertaken by mobile phone established how much had been eaten. Methods and hypotheses were pre-registered on aspredicted.org (#29519). Data is available on the Open Science Framework.

5.1. Participants

Participants (N=800) were recruited by a market research company to take part in the unrelated online study in Ireland. The sample was broadly nationally representative based on age, gender, working status and residential location. The mean age of participants was 50 (SD = 17) with a range from 18 to 85. Men made up 47% of the sample, 51% had a higher degree, 49% were employed and 62% lived in an urban setting. Participants were told that the study

had two parts. The first could be completed immediately, while the second would be sent to their mobile phone a few days later. Participants were told that they would receive a complimentary giftpack and a €12 fee after completing both parts. They were not told anything about the contents of the giftpack.

5.2. Materials

5.2.1. Food

The target food was a 114g packet of an established brand of chocolate finger biscuits (cookies). The giftpack also contained a box of luxury tea and a branded travel mug.

5.2.2. Portion Cue Labels

Labels were designed by the research team and printed professionally. Primary branding and information was retained, with some images reduced to allow space for the visual cues. Cues were printed on both outer and inner packaging. Dashed white lines appeared on the front of the box, with a double arrow and text reading "1 serving" (Figure 4). These were made more salient by a yellow circle pointing to the cue and reading "Look! New serving size guides!" Additional text read "3 Biscuits = 1 serving." The dashed white lines were repeated on the cellophane wrap on the inner tray, with double arrows and "1 serving (3 biscuits)" printed between lines.

Figure 4: Packets of chocolate biscuits with visual cues to portion size

In the control condition, packages had identical new labels without cues; information was supplied in standard nutritional tables. The serving size of 3 biscuits fell below the generally recommended 100kcals (e.g. British Nutrition Foundation [43] and Public Health England [44]) and resulted in approximately 8 portions per pack.

5.2.3. Measure of Consumption

Participants were randomized to receive the follow-up survey 2, 3 or 4 days after the giftpack. We included this range of days as we needed to ensure variation in the dependent variable, avoiding a situation where almost all participants had either not yet opened or finished the packet. Those who had not finished but eaten some of the biscuits were asked to photograph the inner tray. They received instructions, including example photographs, to ensure that the remaining biscuits were clearly visible. Two raters, both unaware of the study aims, independently assessed the number of biscuits in the images. Inter-rater reliability was 71%. Disagreements were small, evenly distributed across condition and resolved through discussion.

5.2.4. Additional Measures

The first question asked participants what they thought were the study aims. It was then revealed that one aim was to examine whether people notice serving size information on snacks. After taking the photograph, they were asked how many adults and children were in the household, the same questions about noticing the information and its meaning as in Study 1, and how many biscuits they thought were in an appropriate serving. We also asked participants how much they liked the biscuits on a scale from 1 "Dislike very much" to 5 "Like very much."

5.3. Procedure

Following the unrelated online study, participants were told they could provide an address and phone number to take part in a follow-up survey. Parcels were addressed to the participant, sent via courier service in an opaque package (so the contents could not be seen until after opening) and tracked using an online tool. The survey was implemented using LimeSurvey, and sent via text message. Reminder texts were sent periodically to those yet to complete the survey.

6. Study 2: Results

The survey was undertaken by 726 participants (response rate 91%). All questions were answered by 674, with no significant differences by gender, age, education or employment status. Unusable images were provided by 21 (N = 8 (2.23%) in the control condition and 13 (3.54%) in the cue condition, $\chi 2$ (1) = 1.12, p = .29), who were excluded. Just one person

mentioned portion size in relation the study aims. Of the 655 people who answered how much they liked the biscuits, 98% gave a response at or above the midpoint and 91% answered "like somewhat" or "like very much."

Our dependent variable is the number of portions eaten per person in the household per day since the package was opened, with the following three-way categorization: none, one or less portion per person per day and more than one portion per person per day. The recommended portion size was three biscuits. Figures S3-S6 in supplementary material illustrate the distribution of the variable. Figure 5 shows consumption of portions by condition.

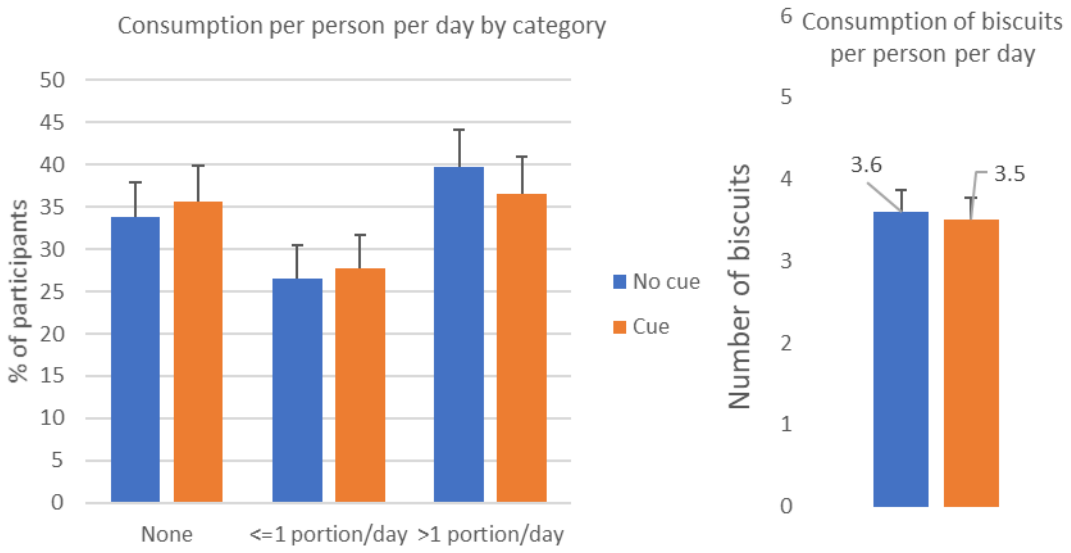

Figure 5: Consumption of portions in Study 2

Significance tests were undertaken by ordinal logistic regression (Table 2). Model 1 shows that the main pre-registered, hypothesized effect was not significant ($p = 0.23$, single-tailed).

Given the gender finding in Study 1, we also carried out an exploratory analysis to test for the same interaction in this study. It is important to note that in this study, gender refers to the gender of the recipient and not necessarily of the eaters. Model 2 reveals a significant interaction by the gender of the recipient ($p = 0.043$, two-tailed). However, the effect is the reverse of Study 1: Households with male recipients ate fewer portions and were not affected by the visual cues, while households with female recipients were. Figure 6 illustrates the interaction. Models 1 and 2 pass standard Brant tests. A separate model fitted only to the data of households in which a woman had received the giftpack, confirmed that households in the cue condition had a significantly lower likelihood of consuming one or more portion per person per day compared to the same households in the control condition." ($\beta = -0.43$, SE = 0.20, $p = 0.03$, two-tailed). We ran an additional analysis with the total number of portions eaten per person per day (range 0 – 8) as the dependent variable and found the same results (see table S2).

Table 2: Ordinal logistic regressions (OLR) and generalized ordinal logistic regressions (GOLR) for consumption of portions per person per day (none, <=1, >1) in Study 2

	(1) OLR	(2) OLR	(3) GOLR		(4) GOLR	
			Open	<=1 v. >1	Open	<=1 v. >1
	B(SE) OR	B(SE) OR	B(SE) OR	B(SE) OR	B(SE) OR	B(SE) OR
Cue	-0.104	-0.374	0.063	0.063	-0.213	-0.213
	(0.142)	(0.195)‡	(0.171)	(0.171)	(0.228)	(0.228)
	.90	.69	1.06	1.06	.81	.81
Male		-0.368			-0.322	-0.322
		(0.203)‡			(0.208)	(0.208)
		.69			.72	.72
Cue*Male		0.581*			0.516‡	0.516‡
		(0.286)			(0.291)	(0.291)
		1.79			1.68	1.68
Children			1.046***	0.153	0.999***	0.087
			(0.290)	(0.240)	(0.292)	(0.244)
			2.85	1.17	2.72	1.09
Cue*Children			-0.756*	-0.523	-0.641‡	-0.406
			(0.377)	(0.339)	(0.381)	(0.344)
			.47	.59	.53	.67
Obs.	674	671	674		671	

‡ p < .10, * p < 0.05; ** p < 0.01; *** p < 0.001. OLR = ordinal logistic regression; GOLR = generalized ordinal logistic regression; B = beta coefficient; SE = standard error; OR = odds ratio. Open refers to the first level of GOLR where coefficients illustrate the effect of independent variables on the likelihood of the packet being opened; <=1 v. >1 refers to the second level of the GOLR where coefficients illustrate the effect of the independent variables on the likelihood of eating 1 or less portions (<= 3 biscuits) per person per day, or more than one portion per person per day.

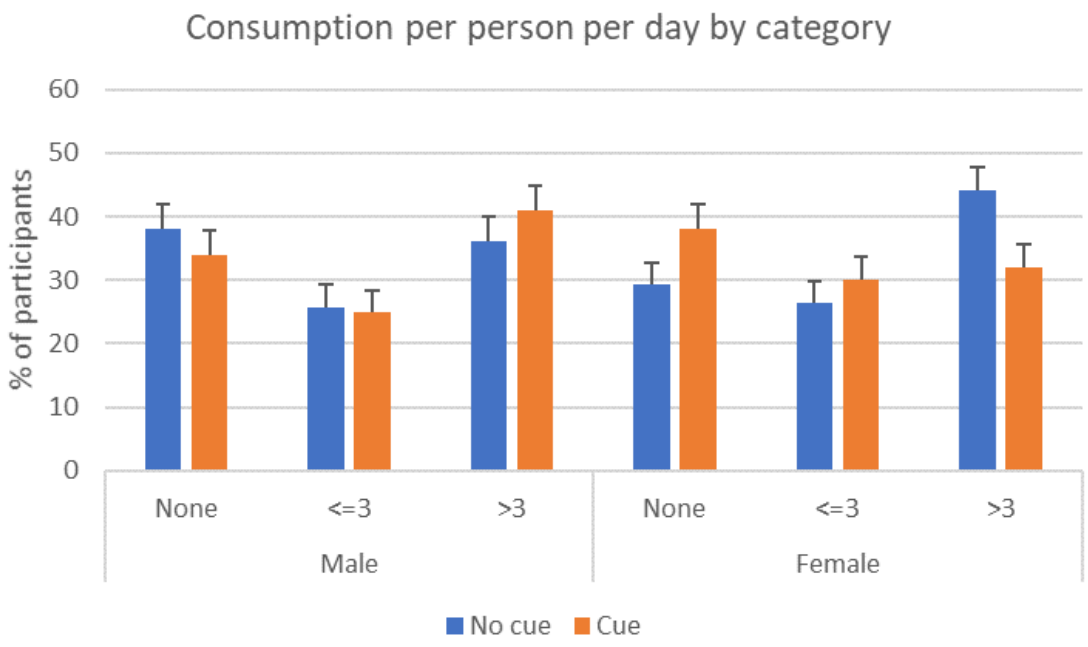

Figure 6: Portions consumed by gender of package recipient in Study 2

Of 674 households in Model 1, 203 (30%) contained children (under-18s). Children's consumption of HFSS foods as snacks is of concern to policymakers. As the target food in this study could arguably be considered a food that is marketed for children, we ran an additional exploratory analysis to check whether the cues had a stronger or weaker effect in households with children. When this variable is added to the regression, it fails the Brant test. Having children in the house affected whether the packet was opened more than whether the household ate more than three biscuits per person per day. Model 3 is therefore a generalized ordinal logistic, which estimates separate coefficients for these two boundaries. Again, there is a significant interaction. Households with children were more likely to open the packet, but this effect was significantly reduced in the cue condition. There was no effect of the cue on consumption once the packet was opened. A separate model fitted only to the data of households with children, with and without control variables, confirmed a lower likelihood of opening the packet in the cue condition ($\beta = -0.55$, SE = 0.262, $p = 0.036$, two-tailed). The

associated effect-size is substantial: 30% of households with children in the cue condition did not open the packet, versus 17% in the control condition.

Model 4 includes both the above interactions and finds the coefficients only marginally reduced (and further tests find no three-way interaction), implying that the gender effect may be partly, but not only, due to parental behavior. Adding control variables for age, educational level and working status leaves the effects broadly unchanged, but reveals that where the recipient had a degree their likelihood of consuming more than the recommended portion was lower ($\beta = -0.392$, SE = 0.148, $p < 0.01$).

Participants in the cue condition were substantially more likely to say that they observed the serving size information (49% v. 14%, $\chi^2(1)= 98.76$, $p<0.001$). When asked how many chocolate fingers they thought constituted an appropriate portion size, participants gave answers that ranged from 0-30 with a mean of 5.23 (3.41). There was no substantial difference in the portion size perceived to be appropriate by those in the control condition (M = 5.37, SD = 3.93) compared to those in the cue condition (M = 5.10, SD = 2.80). Compared to Study 1, more respondents said that they thought the information was a health recommendation (31% from the government, 23% from the company). Just 15% understood correctly that the manufacturer is free to print what it likes.

7. Study 2: Discussion

Visual cues did not have an overall impact on consumption. Yet, as in Study 1, they were associated with different patterns of behavior among specific subgroups: households with female recipients of the giftpack and those with children. The effect of gender is more

complex in this study than in Study 1, because we could not measure the gender of the eater, only the recipient. It is important that gender effects are considered in this context. This is still meaningful, as the recipient is a gatekeeper in much the same way as one member of a household may shop for the entire household. Some caution is also warranted, since we did not hypothesize these specific interactions. However, the results persist with the inclusion of control variables and alternative model specifications.

8. General Discussion

There was no main effect of the visual cues in either study. Men were more likely to eat some or all of the chips than women in Study 1 and so, although these were not pre-registered hypotheses, we tested for gender interaction effects. While the visual cue had a stronger effect on men in Study 1, it had a stronger effect on households with a female recipient in Study 2. One explanation for the different effects by gender in Studies 1 and 2, and for households with children in Study 2, is that placing salient visual cues on snack packaging is more effective among the subgroups inclined to consume more of that type of snack. Study 1 employed a salty potato snack; Study 2 a sweet chocolate snack. Men were more likely to eat more portions in Study 1; households with female giftpack recipients and children ate more portions in Study 2. Prior research on snack preferences in other countries suggests that men are more inclined to eat salty snacks and women sweet snacks [40, 45]. When the visual cues were present, the groups with higher consumption were the groups whose behavior was altered. Given this overall pattern of results, we conclude that putting salient visual cues to portion size on packets, in the form of stripes that demarcate each portion, holds some promise but needs further investigation. While we did not record a significant overall effect,

the findings suggest that the intervention may reduce consumption of HFSS snack foods for those subgroups of consumers most inclined to exceed the recommended serving size.

In considering the implications of these studies, at least two other results are noteworthy. First, salient visual cues increased the proportion of consumers who observe portion size information substantially. Second, changes in consumption occurred despite widespread confusion about what one serving size means – consumers' responses were almost random. The impact of visual cues might therefore be stronger if regulatory policy, or industry practice, introduced such cues in combination with messages designed to convey a clear understanding about what the cues signify.

8.1 Strengths and Limitations

These studies had a number of clear strengths. Unlike much work in this area, the experiments involved real food choices and consumption behavior, undertaken by participants who were not aware that their behavior constituted part of a study. A particular strength of Study 2 was a method that could combine controlled experimental manipulation of packaging with observation of food consumption within the realistic setting of the family home.

However, as with all studies, there are a number of important limitations that affect the strength of inferences that might be drawn. Firstly, the current experiments used only two snack foods, with packaging that was arguably convenient for introducing the sort of visual cue we deployed. However, over 97% of participants in each study reported that they liked each type of snack food, which indicates that they were not products catering to niche tastes.

The extent to which the findings generalize across the range of food products requires further investigation.

Secondly, although we successfully measured consumption in the home in Study 2, we could not observe how it was distributed across households of different sizes and compositions. The number of possible combinations is too great for analysis with a sample size that is feasible for this kind of trial. Neither did we measure the exact number of biscuits eaten by each individual. Our outcome measure is, therefore, subject to some measurement error. Note, however, that such error would have occurred similarly for both control and treatment groups, and that random measurement error would statistically dampen the effects we report.

Thirdly, we did not pre-register hypotheses relating to interaction effects and yet we found strong effects of gender in both studies and an interaction with children in Study 2. The effect of gender on portion size and portion size interventions is complex. Two meta-analyses on the portion size effect have found conflicting results, with one finding no overall effect of gender, and the other finding that men are considerably more prone to the portion size effect than women [6, 15]. In one study that is comparable to our Study 1, 46% of men but only 15% of women were more likely to eat an entire pack of potato chips that were meant to contain multiple portions [40]. Few intervention studies appear to have examined interaction effects with gender, but one that did found strong gender effects. Werle et al. (2016) found that plain packaging had no effect on women's consumption but increased men's consumption, while low-fat packaging had no effect on men but increased women's consumption [33]. They were not testing a similar intervention to ours, but it does indicate that gender effects are likely to be important and merit consideration.

Lastly, and importantly, the studies offer only a snapshot of the possible effect of introducing visual cues; they give no insight into how any effect might evolve over time. There are multiple possibilities. On the one hand, if cues are introduced on many foods and become common, this may increase attention paid to portion size, strengthening the impact. Salient visual cues could become a feature of dialogue between parents and children about appropriate treats. On the other hand, consumers might learn to ignore visual cues over time and hence become immune to them, even if the cues are initially striking. We found widespread confusion over who makes portion size recommendations on packaging. Individuals react differently to portion sizes depending on who they believe has made the recommendation [10]. Standardizing and promoting the source of portion size information, coupled with visual cues, may have a greater influence on behavior than visual cues alone. Nevertheless, overall, the findings we present offer some promise. Salient visual cues might constitute one useful tool for policymakers and others trying to reduce excessive consumption of HFSS snack foods, including in the family home.

References

1. World Health Organization: *Obesity and Overweight.* Retrieved 11th June 2020, from https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight
2. Marteau TM, Hollands GJ, Shemilt I, Jebb SA: Downsizing: policy options to reduce portion sizes to help tackle obesity. *BMJ.* 2015, *351:*h5863.
3. Wada Y, Tsuzuki D, Kobayashi N, Hayakawa F, Kohyama K: Visual illusion in mass estimation of cut food. *Appetite.* 2007, *49:*183-190.
4. Ordabayeva N, Chandon P: In the eye of the beholder: Visual biases in package and portion size perceptions. *Appetite.* 2016, *103:*450-457.
5. Rolls BJ, Morris EL, Roe LS: Portion size of food affects energy intake in normal-weight and overweight men and women. *Am. J. Clin. Nutr.* 2002, *76:*1207-1213.
6. Zlatevska N, Dubelaar C, Holden SS: Sizing up the Effect of Portion Size on Consumption: A Meta-Analytic Review. *J. Mark.* 2014, *78:*140-154.
7. Piernas C, Popkin BM: Increased portion sizes from energy-dense foods affect total energy intake at eating occasions in US children and adolescents: patterns and trends by age group and sociodemographic characteristics, 1977-2006. *Am. J. Clin. Nutr.* 2011, *94:*1324-1332.
8. Zuraikat FM, Smethers AD, Rolls BJ: Potential moderators of the portion size effect. *Physiol. Behav.* 2019, *204:*191-198.
9. The Grocer: *Revealed: 40% of young binge on crisps and 75% skip meals.* . Retrieved 30th January 2020, from https://www.thegrocer.co.uk/snack-report-2015/revealed-40-of-young-binge-on-crisps-and-75-skip-meals/512721.article
10. Versluis I, Papies EK: The role of social norms in the portion size effect: reducing normative relevance reduces the effect of portion size on consumption decisions. *Front. Psychol.* 2016, *7:*756.
11. Marchiori D, Papies EK, Klein O: The portion size effect on food intake. An anchoring and adjustment process? *Appetite.* 2014, *81:*108-115.
12. Steenhuis I, Poelman M: Portion Size: Latest Developments and Interventions. *Curr Obes Rep.* 2017, *6:*10-17.
13. Raghoebar S, Haynes A, Robinson E, Van Kleef E, De Vet E: Served portion sizes affect later food intake through social consumption norms. *Nutrients.* 2019, *11:*2845.
14. Kerameas K, Vartanian LR, Herman CP, Polivy J: The effect of portion size and unit size on food intake: Unit bias or segmentation effect? *Health Psychol.* 2015, *34:*670-676.
15. Hollands GJ, Shemilt I, Marteau TM, et al.: Portion, package or tableware size for changing selection and consumption of food, alcohol and tobacco. *Cochrane Database Syst Rev.* 2015:CD011045.
16. Knai C, Petticrew M, Douglas N, et al.: The Public Health Responsibility Deal: Using a Systems-Level Analysis to Understand the Lack of Impact on Alcohol, Food, Physical Activity, and Workplace Health Sub-Systems. *Int J Environ Res Public Health.* 2018, *15*.
17. Knai C, Petticrew M, Scott C, et al.: Getting England to be more physically active: are the Public Health Responsibility Deal's physical activity pledges the answer? *Int. J. Behav. Nutr.* 2015, *12*.
18. Gollust SE, Barry CL, Niederdeppe J: Americans' opinions about policies to reduce consumption of sugar-sweetened beverages. *Prev. Med.* 2014, *63:*52-57.
19. Mata J, Hertwig R: Public Beliefs About Obesity Relative to Other Major Health Risks: Representative Cross-Sectional Surveys in the USA, the UK, and Germany. *Ann. Behav. Med.* 2018, *52:*273-286.

20. Nuffield Council on Bioethics: *Public health: ethical issues.* Retrieved 12th June 2020, from https://www.nuffieldbioethics.org/wp-content/uploads/2014/07/Public-health-ethical-issues.pdf
21. Lennard D, Mitchell V-W, McGoldrick P, Betts E: Why consumers under-use food quantity indicators. *Int. Rev. Retail. Distrib.* 2001, *11:*177-199.
22. Cowburn G, Stockley L: Consumer understanding and use of nutrition labelling: a systematic review. *Public Health Nutr.* 2007, *8:*21-28.
23. Just DR, Payne CR: Obesity: Can Behavioral Economics Help? *Ann. Behav. Med.* 2009, *38:*s47-s55.
24. Festila A, Chrysochou P: Implicit communication of food product healthfulness through package design: A content analysis. *J. Consum. Behav.* 2018, *17:*461-476.
25. Yarar N, Machiels CJA, Orth UR: Shaping up: How package shape and consumer body conspire to affect food healthiness evaluation. *Food Qual. Prefer.* 2019, *75:*209-219.
26. Ilyuk V, Block L: The Effects of Single-Serve Packaging on Consumption Closure and Judgments of Product Efficacy. *J. Consum. Res.* 2016, *42:*858-878.
27. Mantzari E, Hollands GJ, Pechey R, Jebb S, Marteau TM: Perceived impact of smaller compared with larger-sized bottles of sugar-sweetened beverages on consumption: A qualitative analysis. *Appetite.* 2018, *120:*171-180.
28. Bui M, Tangari AH, Haws KL: Can health "halos" extend to food packaging? An investigation into food healthfulness perceptions and serving sizes on consumption decisions. *J Bus Res.* 2017, *75:*221-228.
29. Argo JJ, White K: When do Consumers Eat More -- the Role of Appearance Self-esteem & Food Packaging Cues. *J. Mark.* 2012, *76:*67-80.
30. Aerts G, Smits T: The package size effect: How package size affects young children's consumption of snacks differing in sweetness. *Food Qual. Prefer.* 2017, *60:*72-80.
31. Deng X, Srinivasan R: When do Transparent Food Packages Increase (or Decrease) Food Consumption? *J. Mark.* 2013, *77:*104-117.
32. Bollard T, Maubach N, Walker N, Ni Mhurchu C: Effects of plain packaging, warning labels, and taxes on young people's predicted sugar-sweetened beverage preferences: an experimental study. *Int J Behav Nutr Phys Act.* 2016, *13:*95.
33. Werle COC, Balbo L, Caldara C, Corneille O: Is plain food packaging plain wrong? Plain packaging increases unhealthy snack intake among males. *Food Qual. Prefer.* 2016, *49:*168-175.
34. Cheema A, Soman D: The Effect of Partitions on Controlling Consumption. *J. Mark. Res.* 2008, *45:*665-675.
35. Roose G, Van Kerckhove A, Huyghe E: Honey they shrank the food! An integrative study of the impact of food granularity and its operationalization mode on consumption. *J Bus Res.* 2017, *75:*210-220.
36. Neyens E, Aerts G, Smits T: The impact of image-size manipulation and sugar content on children's cereal consumption. *Appetite.* 2015, *95:*152-157.
37. Aerts G, Smits T: Do depicted suggestions of portion size on-pack impact how much (un)healthy food children consume. *Int J Consum Stud.* 2019, *43:*237-244.
38. McGale LS, Smits T, Halford JCG, Harrold JA, Boyland EJ: The influence of front-of-pack portion size images on children's serving and intake of cereal. *Pediatr Obes.* 2020, *15:*e12583.
39. Versluis I, Papies EK, Marchiori D: Preventing the pack size effect: exploring the effectiveness of pictorial and non-pictorial serving size recommendations. *Appetite.* 2015, *87:*116-126.
40. Rolls BJ, Roe LS, Kral TVE, Meengs JS, Wall DE: Increasing the portion size of a packaged snack increases energy intake in men and women. *Appetite.* 2004, *42:*63-69.

41. Siegel PS: The completion compulsion in human eating. *Psychol. Rep.* 1957, *3:*15-16.
42. Sheen F, Hardman CA, Robinson E: Plate-clearing tendencies and portion size are independently associated with main meal food intake in women: A laboratory study. *Appetite.* 2018, *127:*223-229.
43. British Nutrition Foundation: *Find Your Balance.* from https://www.nutrition.org.uk/attachments/article/1193/Find%20your%20balance_%20booklet.pdf
44. Public Health England: *Change4Life.* Retrieved 9th June 2020, from https://www.gov.uk/government/news/phe-launches-change4life-campaign-around-childrens-snacking
45. Zaborowicz K, Czarnocińska J, Galiński G, et al.: Evaluation of selected dietary behaviours of students according to gender and nutritional knowledge. *Rocz Panstw Zakl Hig.* 2016, *67:*45-50.