RUNNING HEAD: FOOD COMPOSITION AND PREFERENCE

**Does the visual composition of a dish influence
the perception of portion size and hedonic preference?**

Jessica Rowley & Charles Spence

Crossmodal Research Laboratory, The University of Oxford

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CORRESPONDENCE TO: Prof. Charles Spence, Department of Experimental Psychology,
University of Oxford, Oxford, OX1 3UD, UK. E-mail: charles.spence@psy.ox.ac.uk

ABSTRACT

We report two experiments designed to assess how the plating (i.e., visual composition) of a dish influences people's hedonic preferences and their perception of portion size. In Experiment 1 (conducted online; $N = 122$), we examined whether varying the orientation of the food on the plate (either vertically stacked or horizontally arrayed) would affect people's ratings of liking (of the visual arrangement), willingness-to-pay for the dish, artistic value (how artistic the dish looks), and perceived portion size. Experiment 2 ($N = 124$) extended this research to a naturalistic dining context, demonstrating the influence of both plating arrangement (horizontal vs. vertical) and centrality (centred vs. offset plating) on the same ratings. In both experiments, the plate of food was rated as constituting a larger portion when the elements were arrayed-horizontally rather than stacked vertically. Additionally, the centrally-plated dessert was rated as a larger portion than the offset version of exactly the same dish. The food was also liked more and the participants/diners were willing to pay more for it when horizontally and/or centrally arranged. These results provide important guidelines for enhancing the visual arrangement of a dish, in order to increase enjoyment, and possibly also nudge consumers toward better food choices.

KEYWORDS: PLATING; PRESENTATION; STACKING; PORTION SIZE ESTIMATION

Introduction

Nowadays, many chefs are growing increasingly conscious/concerned about how their food looks. Indeed, together with the sheer variation and ingenuity in the visual composition of dishes that one sees on sites such as Instagram's The Art of Plating, Apicius's 1st Century assertion that people eat first with their eyes would seem remarkable apposite (e.g., Apicius, 1936 Spence, 2015; Spence et al., 2016). Currently, many chefs approach the plating of food in a natural manner, where the visual aspects of composition are refined through an intuitive and iterative process in the kitchen. As such, it becomes increasingly important to investigate empirically how differences in the visual arrangement of the food on the plate may influence a diner's expectations, and their subsequent evaluations (see Spence, Michel, Piqueras-Fiszman, & Deroy, 2014, for a review). Indeed, subtle changes in the visual composition of a dish may affect a diner's perception of its taste/flavour, how much the food is liked (e.g., Michel et al., 2014; Zampollo, Kniffin, Wansink, & Shimizu, 2012; Zellner, Lankford, Ambrose, & Locher, 2010; Zellner, Loss, Zearfoss, & Remolina, 2014; Zellner et al., 2011) and even how much a diner is willing to pay for it (Michel, Velasco, Fraemohs, & Spence, 2015). Additionally, visual appearance cues have been shown to influence people's judgments and decisions, such as evaluating and choosing the size of a portion of food (Aydinoğlu & Krishna, 2011; Szocs & Lefebvre, 2017).

The aim of the two experiments reported here (one study conducted online, the other in a naturalistic dining environment) was to examine the visual composition of a plate of food on both people's subjective perception of the size of the portion and their hedonic preferences (i.e., how much they like the visual arrangement, their willingness-to-pay for a dish, and how artistic they believe the dish looks).

Visual arrangement and hedonic preferences

Research exploring food aesthetics has demonstrated that several important factors involved in the visual composition of a dish during plating may influence the consumer's evaluations of the food. Many of these factors are derived from novel culinary trends and guidelines established by chefs around the world. This includes recent trends by chefs toward asymmetric plating (i.e., when all of the edible elements are crowded onto just one side of the plate; see Spence et al., 2014; Spence & Piqueras-Fiszman, 2014; Styler, 2006; Velasco, Michel, Woods, & Spence, 2016) and the increasingly artistic representations of food that one sees more generally (see Spence et al., 2014, for a review).

In addition, research on the topic of visual aesthetics has consistently shown that the location of food on the plate influences both how it is perceived and how much people like it. For example, those items that occupy central locations tend to be preferred (see Michel et al., 2015; Palmer, Schloss, & Sammartino, 2013; Velasco et al., 2016), and preference for the composition decreases, the further away the items are moved from the centre (Palmer, Gardner, & Wickens, 2008). More specific manipulations to the position of the main item within a composition (together with the food colours used) can also influence diner's perception, with colourful dishes where the main item is placed away from the diner being perceived as more creative, and liked significantly more, than off-centred monochrome dishes (Roque, Guastavino, Lafrairec, & Fernandez, 2018).

Spence et al. (2014) demonstrated that the artistic presentation of a salad, resulted in the dish being considered as significantly more artistic, more complex, and more liked than either a regular salad presentation or a neat presentation (with all three presentations containing the same ingredients). While, as one might perhaps expect, the intuitions of the successful chef often turn out to be preferred by the public at large (when assessed in scientific experiments), it is important to note

that this is not always the case. When preferences for visual compositions are explored by drawing parallels with the aesthetics of the visual arts (see Spence, 2017b, for a review), it seems that some of these intuitions turn out to be less preferred. For instance, visually symmetrical compositions have been shown to be preferred over the unbalanced, or asymmetrical (Zellner et al., 2011), the latter currently popular amongst some chefs.

Subtle differences in plating can evidently influence consumers' aesthetic evaluations of a dish (Michel, Velasco, Gatti, & Spence, 2014), their preferences (Zellner et al., 2011), and even how much they are willing to pay for it (Michel et al., 2015; Roque et al., 2018; Velasco et al., 2016). What the diner sees on a plate generates an array of expectations and subsequent evaluations concerning the taste, flavour, and enjoyment of a given dish (Piqueras-Fiszman & Spence, 2015; Spence & Piqueras-Fiszman, 2014).

Altering the arrangement of the food on the plate (either stacking the food vertically or spreading it out horizontally) been shown to influence the perception of portion size and the quantity of food consumed (Szocs & Lefebvre, 2017). According to the latter's findings, consumers actually perceive there to be less food but eat more when the elements are stacked vertically as compared to when the same food is presented flat (horizontally) against the surface of a plate. Previous research examining the influence of visual composition on hedonic preferences has typically relied on trends set by chefs, such as balance, the number of elements, and centrality (Roque et al., 2018; Woods et al., 2016; Zellner et al., 2011). Although the impact of a food's visual orientation on health-related behaviours has been explored previously (Szocs & Lefebvre, 2017), no one has examined the influence of orientation (arrayed horizontally vs. stacked vertically) on people's hedonic preferences.

Stacking food is a popular plating technique (Choi, 2014), and both vertical food presentation and the more ‘traditional’ horizontal presentation are common plating techniques used in many restaurants (see Horwitz & Singley, 2004; Restaurant News, 2016). The two experiments reported here were designed to investigate how altering the plating of the food in a dish (contrasting a vertical vs. horizontal arrangement), influences consumers’ hedonic preferences (including their liking of the visual presentation, their willingness-to-pay, and how artistic they rate the dish’s appearance) as well as their subjective evaluations of portion size. Additionally, the second study was designed to explore whether the centrality of the food within a dish (whether the food is presented in an asymmetrical fashion or more traditionally centred in the middle of the plate) would influence portion size estimates and the viewer’s hedonic evaluations of the food concerned. As such, this research attempts to offer further understanding concerning the link between a chef’s intuitive principals for plating and the preferences of the consumers whom they serve.

Importantly, the evaluation of food in real-consumption situations sometimes differs from what is seen when foods are only presented visually (Jimenez et al., 2015). Experiment 2 was therefore conducted in a naturalistic dining environment to further investigate the influence of orientation on consumer preferences in a real-world dining context.

Based on the above, several hypotheses were tested in the present study:

H1: Participants will associate stacked plating with increased liking, increased artistic value (as this style of plating is usually achieved by more experienced and proficient chefs; Choi, 2014), and an increased willingness-to-pay for the dish (as this style of plating can be directly linked to higher-end dining environments where prices may be inflated relative to other classes of establishment).

H2: Consumers will perceive a given volume of food as larger if the food is arrayed horizontally (rather than stacked vertically) since a horizontally presented portion presents a larger surface area visually. Given previous findings (Szocs & Lefebvre, 2017), our prediction was that equal volumes of food will be perceived as larger when arranged horizontally (vs. stacked vertically) on the plate.

H3: Diners will express a preference for the dish that is presented centrally, are will also be willing-to-pay more for it, and likely also rate it as more artistic than the same food when presented off-centre.

Experiment 1

The main aim of Experiment 1 was to examine the effects of manipulating the visual composition of plated food on perceived portion size, in an attempt to replicate Szocs and Lefebvre's (2017) findings. The same food elements were either stacked vertically in a tower or else spread-out horizontally over the plate. Experiment 1 also assessed whether these plating manipulations influenced people's liking for the visual presentation of the dish, their rating of its artistic value, and their willingness-to-pay (WTP).

Methods

Participants: An *a priori* power analysis was performed to determine the required sample size for this study. With an $\alpha = .05$ and power = 0.90, the projected sample size needed with this effect size (using G*Power 3.1 software; Faul, Erdfelder, Lang, & Buchner, 2007) was approximately $N = 84$ for the simple between-groups comparison. Thus, the proposed sample size of 122 was

deemed more than adequate to address the main objective of this study. This increased sample size was chosen to allow for both expected attrition and also potentially to allow us to address the additional objectives of controlling for possible mediating factors.

One-hundred and twenty-two participants (63 males and 59 females) were recruited to take part in Experiment 1 using Amazon's Mechanical Turk (<https://www.mturk.com/>), an online academic platform for conducting experimental research. The participants, who ranged in age from 21 to 67 years ($M = 34$ years), received a payment of \$0.50 for taking part. Only those living in the USA were eligible. All of the participants gave their informed consent to take part in the study, which was approved by Oxford's University Medical Sciences Inter-Divisional Research Ethics Committee (approval #MS-R49180/RE001).

Design: A one-factor independent measures design was used, varying the way in which the food was presented (with the same food items either being stacked vertically or else spread out horizontally over the plate). The dependent variables included the estimated portion size, how much the visual arrangement was liked, how artistic the presentation looked, and the participant's WTP for the dish. The participants were randomly assigned to either condition.

Stimuli: Two versions of the same plate of food were created with identical elements varying solely in terms of their composition (i.e., with the elements in the dish stacked vertically vs. spread-out horizontally). In both conditions, the plate of food consisted of a warm salad, weighing 200 grams and containing two slices of mozzarella cheese, two slices of red tomato, and three slices of grilled aubergine (see **Figure 1** for the visual stimuli shown to participants). As previous research suggests that items occupying central locations tend to be preferred over offset items (Velasco et al., 2016; see Palmer et al., 2013, for a review), the food was presented in the centre of a round, white plate.

Once plated, several images were then generated using a camera. These images were taken from a bird's-eye view (cf. Woods et al. 2016).

Figure 1. Warm salad shown to participants in Experiment 1: Vertically-stacked (left) and horizontally-arrayed (right) presentations of the same elements (3 slices of grilled aubergine, 2 slices of tomato, and 2 slices of mozzarella).

Procedure: Instructions were presented online and informed consent was acquired. The participants were then shown either of the versions of the plate of food shown in **Figure 1** for 30 seconds. The plated food image was shown alongside a description of the ingredients. After a few seconds, the plate alone was presented once again alongside several questions regarding the participant's preferences for the composition/dish. The questions assessed liking for the visual presentation of the dish, using a 7-point Likert scale, anchored with 1 ('not at all'), and 7 ('very much'), and how artistic they believed the dish to look, again using a 7-point Likert scale, anchored with 1 ('not very artistic at all'), and 7 ('very artistic'). For WTP, the participants had to indicate how much they would have been willing to pay for the dish by indicating a value on a sliding scale from US \$0-10. The questions also assessed the subjective perception and estimation of portion size using a 7-point Likert scale where 1 is 'tiny' and 7 is 'huge' (Aydinoğlu & Krishna, 2011).

Results

The results were analyzed using a series of one-way independent measures analyses of variance (ANOVAs), with presentation (stacked-vertically vs. arrayed-horizontally) as the independent variable. The analyses were performed on each of the four different dependent measures (estimated portion size, liking of the visual presentation, how artistic the dish looked, and WTP). See **Figure 2** for a summary of the results.

Figure 2. Participants' ratings for estimated portion size, liking of visual arrangement, WTP, and artistic value for the vertically-stacked vs. horizontally-arrayed presentation in Experiment 1. The error bars indicate the standard error of the mean. Estimated portion size, liking, and artistic value were coded on a 7-point Likert scale. WTP was coded from 0-10 (USD). *** $p < .001$.

Estimated portion size: The analysis explored the difference in estimated portion size as a function

of the way in which the dish was presented. Perhaps unsurprisingly, the analysis revealed a significant difference in estimated portion size [$F(1, 122) = 83.81, p < .001$, partial $\eta^2 = .41$], with the horizontally-arrayed plating arrangement rated as containing significantly more food ($M=5.56$, $SE = .157$; with a rating of 7 being ‘huge’ and 1 as ‘tiny’) than the vertically-stacked arrangement ($M = 3.39$, $SE = .179$).

Liking: The participants liked the horizontally-arrayed food significantly more than the vertically-stacked arrangement ($M = 4.82$, $SE = .173$ vs. $M = 2.95$, $SE = .171$) [$F(1, 122) = 59.13, p < .001$, partial $\eta^2 = .33$].

WTP: The participants were willing to pay significantly more for the food when it was arrayed-horizontally on the plate ($M= \$5.31$, $SE = \$0.24$) than when stacked vertically ($M = \$3.29$, $SE = \$0.27$) [$F(1, 122) = 30.42, p < .001$, partial $\eta^2 = .20$].

Artistic value: There was no significant difference in terms of ratings of how artistic the horizontally-arrayed vs. vertically-stacked plates of food looked [$F(1, 122) = .362, p = .58$].

Correlations: Additional Pearson correlations were conducted in order to assess the relationship between ratings of liking, artistic value, and WTP individually with estimated portion size. These analyses revealed a positive relationship between liking and estimated portion size for both the vertically-stacked ($p = .043$) and horizontally-arrayed ($p = .021$) presentations, thus suggesting that as estimated portion size increased, liking for the visual arrangement of the dish also increased regardless of the style of presentation (cf. Woods et al., 2016). A significant positive relationship was also observed between estimated portion size and WTP for both the horizontally-arrayed ($p = .025$) and vertically-stacked presentations ($p = .041$). This result suggests that, for both styles of presentation, the participants were willing to pay more for the dish as estimated portion size increased. In terms of artistic value, there was a marginally significant negative correlation

between artistic ratings of the dish and estimated portion size for the vertically-stacked ($p = .049$) presentation while no such correlation was found for the horizontally-arrayed presentations.¹

Discussion

In line with Szocs and Lefebvre's (2017) recent findings, and the hypotheses outlined earlier, the results of Experiment 1 clearly demonstrate that variations in the way in which food is presented affect portion size estimates and hedonic preferences. When the visual orientation of the food was altered, whilst holding the actual amount of food constant, the participants perceived there to be significantly more food when the elements were plated in a horizontal fashion (i.e., flat to the plate), as compared to those who estimated the portion size after looking at the same elements stacked vertically instead (a mean difference of 2.17 on a 7-point scale, reflecting an increase of 64%).

Additionally, and contrary to Hypothesis 1, food presented horizontally was liked significantly more than the same food when stacked vertically (a difference of 1.87, on a 7-point scale, representing an increase of more than 63%), and the WTP was also significantly higher for the dish (a difference of \$2.02, representing an increase of 61%). It is, though, important to note that these results may be driven by the impact of the plating arrangement on the perceived quantity of food. Perhaps when a vertically-stacked dish and a horizontally-arrayed dish are perceived to have the same amount of food (assuming that such conditions are achievable), then the vertical presentation will be preferred as it will be viewed as more high-end. If, however, the vertical

¹ Additional Analyses of Covariance (ANCOVAs) were conducted in order to examine whether gender, hunger, or BMI were significant covariates. Each ANCOVA was run separately with food presentation as the independent variable, and estimated portion size as the dependent variable. The ANCOVAs revealed that gender [$F(1, 122) = 34.2$, $p = .34$], hunger [$F(1, 122) = 16.4$, $p = .15$], and BMI were not significant covariates [$F(1, 122) = 20.3$, $p = .24$].

presentation obscures the actual quantity of food on the plate, as when using a bird's-eye view as (as in Experiment 1), then participants may prefer the horizontally-presented dish, simply because there appears to be more food.

Thus, the results of Experiment 1 provide relevant evidence for those considering how best to present their dishes visually (e.g., on a restaurant website or Instagram post). However, the findings reported so far are clearly of limited relevance as far as the influence of visual plating factors on actual consumption are concerned given two factors: First, it is not altogether clear whether the impact of plating on people's expected hedonic responses to the food would necessarily carry-over to influence their actual ratings on consuming the dish (this is, of course, a general limitation when using online-only assessment methods). Here it is important to note that while sensory and hedonic expectations often influence people's ratings of a product or dish in many occasions/situations, this is by no means always the case (e.g., see Wang, Reinoso, Carvalho, Persoone, & Spence, 2017; Zellner et al., 2010). The consumption experience in general, and taste/flavour perception in particular, may influence several aspects of consumer perception, in a way in which merely viewing an image of the plate of food might not (Spence, 2017a). Furthermore, another limitation with Experiment 1 was that the bird's-eye view of the dish meant that the participants were not really able to get any sense of the height of the vertical stack of food.

Our second study was therefore designed to address these potential limitations by assessing whether plating would exert a similar effect under naturalistic dining conditions in which the participants actually evaluated the dish that they consumed and which they could view from various angles. Experiment 2 was conducted in a large naturalistic dining environment, namely a dining room at an Oxford college (Lady Margaret Hall; <http://www.lmh.ox.ac.uk>). Here it is worth stressing how few studies previously have attempted to assess participants' hedonic preferences

during a real consumption experience outside of the science lab (see Lahne & Zellner, 2015; Michel et al., 2014; Zellner et al., 2010, 2011, 2014, for rare exceptions). It is obviously important to confirm whether the observations from online studies extend to the more ecologically-valid environments where consumption occurs as well.

Experiment 2

Methods

Sample: An a priori power analysis was performed to determine the required sample size for this study. With an $\alpha = .05$ and power = 0.90, the projected sample size needed with this effect size (using G*Power 3.1 software) was approximately $N = 130$ for this simple between-groups comparison. The proposed sample size of 140 would have been adequate for the main objective of this study. However, given that our total sample of 124 actually fell slightly under this value,² and thus the results should be considered in light of this limitation. The 140 diners consisted of students (c. 60%), their parents, friends, and families (c. 30%), and a small number of academics and college staff (c. 10%). All of the participants were at least 18 years of age. The study was conducted in the dining hall of Lady Margaret Hall College, Oxford University. The occasion was a Formal Hall dining event, one of many hosted in the college. The event was advertised as an ‘experimental dining experience’ throughout the college, one week prior to the event. Only the data from diners who agreed to participate in the study and who successfully completed the questionnaire booklet are reported ($N = 124$).

² Note that such variations are a more-or-less unavoidable aspect of conducting studies in live dining situations where it is more difficult to control numbers precisely, and where adding a few extra participants to reach the desired sample size is not an option.

Design: A two-factor mixed measures design was used. The two independent variables included the dish type (starter vs. dessert) and the plating style with four experimental conditions ('stacked-vertically' or 'arrayed-horizontally' for the starter, and 'centred' or 'offset' for the dessert). Once again, the dependent variables included estimated portion size, liking of the visual arrangement of the food, how artistic the dish was perceived to be, and WTP. The diners were asked how much they would be WTP for the dish by indicating a value on a scale from £0-10.

Stimuli: The meal consisted of three courses, however, only the starter and dessert were manipulated as part of this study. All diners were served the same starter consisting of either a meat pâté or mixed vegetable pâté for vegetarians. All of the food was presented on round, white plates (10 inch diameter). One group of diners (N = 62) was served the 'vertically-stacked' starter, followed by the 'centred' dessert, while the second group (N = 62) was served the 'horizontally-arrayed' starter, followed by the 'offset' dessert.

Two visual arrangements of the starter were created in collaboration with the Head Chef. In both conditions, the plated starter consisted of a cylinder of either chicken-liver and mixed vegetable pâté (or the vegetarian mixed vegetable pâté), a baked crouton, pickled vegetables including carrot, baby onions, gherkin and cauliflower, a drizzle of lemon dressing, all topped with finely chopped coriander, small salad leaves, and spring onion. The elements in the starter were either stacked-vertically or else arrayed-horizontally (see **Figure 3**).

Similarly, for the dessert, two distinct visual plating arrangements were created in collaboration with the head chef. The dessert was plated either 'centred' or 'offset' and once again consisted of the same quantity of exactly the same ingredients. In the 'centred' condition, all of the elements of the dish were presented in the centre of the plate. In the offset condition, the same composition was used to ensure that exactly the same surface area was covered by the food, but this time the

overall food composition was plated in an offset manner instead. In both conditions, the dessert consisted of a cylindrical vanilla, white chocolate, and raspberry cheesecake served with a quenelle of milk chocolate mousse, raspberry coulis, and topped with fresh raspberries, fresh mint and a sprinkling of icing sugar (see **Figure 3**).

Figure 3. Plated food presented to the diners in Experiment 2: (A) vertical presentation; (C) horizontal presentation. The presentation of the dessert was either slightly offset (B) or central (D).

Procedure: For the Formal Hall event, the Lady Margaret Hall dining hall was set with 12 rectangular tables each seating up to 14 guests. The diners had been made aware prior to the meal that it would be an experimental dining event. The tables were dressed with a white tablecloth, conventional cutlery, and glassware. The room was divided into two groups of 6 tables, to enable the waiters to serve the right plating at the correct tables.

Upon entering the dining hall, the guests were seated randomly and evenly in one of the two groups of tables. The style of visual arrangement the diners received depended on the table on which they sat. Each table received the same visual arrangement for both the starter and dessert courses. This ensured that no diners would have been likely to observe a different plating style from another table. Those sitting at tables at one end of the hall were given the vertically-stacked starter and the centred dessert, while those sitting at tables at the other end were given the same food but the starter was presented horizontally-arrayed and the dessert offset. The questionnaire was briefly explained, including the order in which the questions should be answered in relation to the course served. For both courses, the diners were instructed to answer any questions relating to liking of the visual arrangement, subjective perception of how artistically the food elements were arranged on the plate, and their estimation of the portion size prior to consumption. They were also informed that they would have a few minutes in-between the courses in which to complete the final questionnaire items relating to WTP placed on the following page.

The questionnaires were presented in double-sided A4 booklets, with each positioned next to each place setting. The participants responded to the questions assessing liking of the visual arrangement, portion size, how artistic they thought the dish looked, and WTP following the same direction as in Experiment 1.

Results

The results were analyzed using a series of one-way ANOVAs. Two separate analyses were conducted to examine the influence of the dishes visual arrangement for both the starter (vertically-stacked or horizontally-arrayed) and dessert (centred or offset) course on the dependent variables.

The analyses were performed on each of four different dependent variables: liking of the visual arrangement, rating of how artistic the dish appears, estimated portion size, and WTP).

Starter

Estimated portion size: There was a significant effect of visual arrangement on estimated portion size [$F(1, 122) = 4.04, p = .05$, partial $\eta^2 = .18$], with the diners once again rating the vertically-stacked starter as constituting a smaller portion ($M = 2.77, SE = .075$) than the horizontally-arrayed version of exactly the same elements ($M = 3.19, SE = .075$). These results therefore suggest that when food is stacked vertically, diners perceive there to be slightly less food on the plate as compared to when the food is laid flat to the plate.

Liking: There was a significant effect of visual arrangement on liking [$F(1, 122) = 68.62, p < .001$, partial $\eta^2 = .60$], with the diners liking the visual arrangement of the horizontally-arrayed starter more ($M = 4.82, SE = .172$) than the vertically presented version ($M = 2.92, SE = .127$).

WTP: There was significant effect of visual arrangement on WTP [$F(1, 122) = 68.16, p < .001$, partial $\eta^2 = .60$], with diners being willing to pay more for the horizontally-arrayed starter ($M = £6.46, SD = £1.86$) than for exactly the same food when stacked vertically ($M = £3.34, SD = £2.22$).

Artistic value: The analysis revealed a significant effect of visual arrangement on artistic value [$F(1, 122) = 24.46, p < .001$, partial $\eta^2 = .41$], with diners rating the vertically-stacked starter ($M = 3.15, SE = .120$) as looking significantly more artistic than when the same food was arrayed horizontally instead ($M = 2.29, SE = .120$; see **Figure 4** for a summary of the results).

Dessert

Estimated portion size: The analysis revealed a significant effect of visual arrangement on estimated portion size [$F(1, 122) = 31.57, p < .001$, partial $\eta^2 = .45$], with diners rating the centrally presented dessert as larger ($M = 3.29, SE = .131$) than the offset presentation ($M = 2.31, SE = .116$).

Liking: The analysis revealed a significant effect of visual arrangement on liking [$F(1, 122) = 49.21, p < .001$, partial $\eta^2 = .54$], with diners preferring the visual arrangement of the centrally-presented dessert course more ($M = 4.18, SE = .096$) than the offset dessert ($M = 2.92, SE = .151$).

WTP: The analysis revealed a significant effect [$F(1, 122) = 6.517, p = .012$, partial $\eta^2 = .23$], with diners willing to pay more for the centrally-placed dessert ($M = £5.75, SD = £2.64$) than for exactly the same food when offset ($M = £4.81, SD = £2.54$).

Artistic value: The analysis revealed a significant effect of visual arrangement on artistic value [$F(1, 122) = 20.44, p < .001$, partial $\eta^2 = .38$], with diners rating the offset dessert ($M = 3.60, SE = .188$) as looking significantly more artistic than the same food elements when presented centrally ($M = 2.53, SE = .145$; see **Figure 4** for a summary of the results).

Correlations: As in Experiment 1, additional Pearson correlations were conducted for both the starter and dessert to assess the relationship between ratings of liking, artistic value, and WTP individually with estimated portion size.

Starter

These analyses revealed a positive relationship between liking and estimated portion size for both the vertically-stacked ($p < .001$) and horizontally-arrayed ($p = .001$) presentations, thus suggesting that as estimated portion size increases (and participants perceive there to be more food), liking for the visual arrangement of the dish also increased regardless of the style of presentation (cf. Woods et al., 2016). A significant positive relationship was also observed between estimated

portion size and WTP for both the horizontally-arrayed ($p = .009$) and vertically-stacked presentations ($p = .019$). This result suggests that for both presentation styles the participants were willing to pay more for the dish as the estimated portion size increased. There was no significant correlation between artistic ratings of the dish and estimated portion size for either presentation style.

Dessert

There was a positive relationship between liking and estimated portion size for both the centred ($p = .004$) and offset ($p = .002$) presentations, thus suggesting that as estimated portion size increases (and participants perceived there to be more food), liking for the visual arrangement of the dish also increases regardless of the style of presentation. A significant positive relationship was also observed between estimated portion size and WTP for both the centred ($p = .002$) and offset presentations ($p = .004$). This result suggests that for both styles of presentation the participants were willing to pay more for the dish as the estimated portion size increased. Once again, there was no correlation between artistic value and estimated portion size for either style of presentation.

Figure 4. Mean ratings of each response measure as a function of plating condition for the starter (A) and dessert (B) in Experiment 2. For each course, the participants were asked the following questions: “How would you rate the size of this dish?”; “How much do you like the presentation of this dish?”; “How much (in Pounds Sterling) would you be pay for this dish in a restaurant?”; and “How artistic would you rate the presentation of this dish?” The error bars indicate the standard error of the mean. * $p \leq .05$; *** $p < .001$.

Discussion

The results of Experiment 2 revealed a significant difference in the estimated portion size for the starters as a function of their arrangement. Just as in Experiment 1, diners thought that there was less food when the starter was stacked vertically as compared to when it was arrayed horizontally

(a difference of 0.42, equivalent to an increase of 15%). Additionally, the diners also liked the visual arrangement of the horizontally-arrayed starter more than the vertical arrangement (a difference of 1.87, representing an increase of 63%) and they were willing to pay more for it (£6.46 vs. £3.34 for the vertically presented version; on average, representing a 93% increase) even though they had not been made explicitly aware of the aesthetic intention behind the dish.

Diners in Experiment 2 rated the vertically-stacked starter as appearing more artistic than the horizontally-arrayed starter (a difference of 0.85, where 1 = ‘not very artistic at all’ and 7 = ‘very artistic’, an increase of 37%). This presumably reflects the fact that the initial oblique angle view of the dish meant that the diners were better able to assess the actual height of the stack of food presented, whereas the online participants in Experiment 1 struggled to do so, given the static bird’s-eye view of the dish that they had been presented with.

The results also demonstrate that diners perceived the centrally-presented dessert as containing more food than the off-set dessert (a difference of 0.99, a 43% increase). In addition, and in line with previous research (Michel et al., 2015; Palmer et al., 2013; Velasco et al., 2016; Roque et al., 2018), the results also suggest that the centrally-presented dessert was liked more than the offset dessert (a difference of 1.26, a 30% increase) and diners were willing to pay more for the centrally-presented dessert (on average, £5.75 vs. £5.51, an increase of 4%). The results also suggest that diners rated the offset dessert as looking more artistic than the same food when presented centrally (a difference of 1.07, a 30% increase).

General Discussion

The present research assessed the impact of presenting identical food elements with different visual arrangements on people's sensory perception and hedonic evaluation of the food in terms of portion size, liking of the visual arrangement, artistic value, and their WTP for the dish. Experiment 1 examined the influence of vertically-stacked vs. arrayed-horizontally presentation for the plating of the food. Experiment 2 additionally assessed diners' preferences in response to manipulations of the orientation while additionally exploring evaluative responses to the same food when plated symmetrically centred on the plate, versus when the same ingredients were placed slightly to one side of the plate, in an asymmetrical manner.

Portion size

The results of both of the experiments reported here converge on the conclusion that the horizontal vs. vertical arrangement of the food on the plate exerts a substantial influence over participants' portion size estimates. In particular, participants estimated that there was less food when the elements were stacked vertically than when the same elements were arrayed horizontally. The diners in Experiment 2 also perceived a centrally-plated dessert to be larger than a dessert where the same elements were offset. When evaluating the size of a portion, it has been suggested that we use visible surface area as a heuristic to determine the amount (Szocs & Lefebvre, 2017). This could, at least in part, help to explain why participant's perception of portion size for food presented horizontally, and occupying a greater surface area, is greater as compared to when the same quantity of food is stacked vertically therefore occupying a smaller visible surface area. In future research, it would be interesting to examine whether holding the surface area constant, while altering the orientation of the food presentation, would still lead to the horizontal versus vertical

arrangement manipulation influencing the consumer's portion size estimate. Currently, it is difficult to determine whether the differences in perceived portion size should be attributed to the orientation manipulation or was more influenced by the surface area of the food that they could see. Although the manipulation to the visual composition of the dessert was designed to assess the impact of asymmetrical plating, there were unavoidably still existing variations in elevation across the various elements of this dish. This makes it difficult to determine whether the influence on preferences should be attributed solely to the balance of the dish or to its elevation (orientation). In future research, it may be important to use plating arrangements with identical stimuli (but varying in orientation/location) in order to determine whether one variable influences people's evaluations more than the other.

This is particularly true for Experiment 2, where the difference in ratings may have been attributable to the visibility of the main meat component. In the case of the vertically-stacked dish, the salad leaves were placed atop the main item, hiding it from view. However, in the horizontally-arrayed condition, the meat item was clearly visible and may have made the dish appear more substantial. In future research, it will be interesting to further explore whether omitting or enhancing the visibility of the more substantial/expensive elements within a dish might go some way toward explaining the differences in estimated portion size that were observed. This aside, it is interesting to note that the same quantity of exactly the same ingredients can be perceived differently depending simply on the visual arrangement of those items on the plate.

Overall, these results indicate that both the orientation and the centrality of the main composition of food items on the plate can exert an influence over people's perception of portion size in a real-world dining situation. Additionally, the idea that the centrality of the food can influence estimated portion size is novel.

Liking and WTP

The present findings demonstrate that the visual arrangement of food presented horizontally on a plate is liked significantly more than when the same food is presented vertically. What is more, participants are willing to pay significantly more for the dish. Additionally, a centrally presented dessert was liked more, and diners were willing to pay more for it, than an offset dessert. The correlational analyses conducted for both Experiment 1 and 2 also revealed a positive relationship between estimated portion size and their liking of the visual arrangement, and between estimated portion size and WTP, for both vertical and horizontal presentations. Interestingly, these results suggest that rather than merely liking the orientation of the food, the perception of portion size may be a critical factor in influencing these hedonic evaluations. Larger perceived portion sizes may increase participants' liking of the presentation of the food and thereby increase their WTP for the dish that appears more generous. In turn, these results may offer an explanation for the observed preference for horizontally-presented food (compared to the same food when stacked-vertically). These results also support previous research suggesting that larger (perceived) portion sizes are preferred by consumers/diners (Woods et al., 2016).

In Experiment 2, and as mentioned in the Introduction, the plating of the offset dessert was inspired by a recent trend amongst high-end modernist restaurants to plate their food in an asymmetrical manner. However, in line with previous findings (Michel et al., 2014; Roque et al., 2018; Velasco et al., 2016), it would appear that the more traditional centred style of plating is actually preferred as compared to the same food elements presented in an offset manner. Research on the topic of visual aesthetics goes some way toward explaining this finding, with results consistently showing that items occupying central locations are preferred and tend to receive a higher evaluation (see

Palmer et al., 2013). However, it could also reflect a basic tendency for people to prefer symmetrical over asymmetrical compositions, supporting the idea that the visual balance of the food elements placed on the plate matters (Zellner et al., 2010).

Practical Implications and Conclusions

The results reported here clearly demonstrate that the way in which food is presented visually has a substantial influence on both consumer's perception and estimation of portion size as well as on their hedonic evaluations. By furthering our understanding of the impact of specific manipulations to food presentation we can provide an insight into how they might be used in the future to maximize enjoyment for the consumer, enhance plating styles to increase diner's liking of a dish and their WTP (Michel et al., 2015), control portion size without limiting satisfaction, and provide more opportunity to increase profits for restaurateurs at practically no extra cost (excepting the cost required to ensure the artistic arrangement). In addition, it is possible that making consumers aware of the effects of food presentation techniques, such as orientation and centrality, would allow them to make strategic use of these effects when preparing meals in the home, too (see Spence, 2017a). The research also offers an insight into the evaluation process of consumers when making judgments about their food, suggesting that our hedonic preferences may largely be driven by our perception of the quantity of food (cf. Woods et al., 2016).

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