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The Effect of Spatial Location of Calorie Information on Choice, Consumption and Eye Movements

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Abstract

We manipulated the presence and spatial location of calorie labels on menus while tracking eye movements. A novel "lab-in-the-field" experimental design allowed eye movements to be recorded while participants chose lunch from a menu, unaware that their choice was part of a study. Participants exposed to calorie information ordered 93 fewer calories (11%) relative to a control group who saw no calorie labels. The difference in number of calories consumed was greater still. The impact was strongest when calorie information was displayed just to the right of the price, in an equivalent font. The effects were mediated by knowledge of the amount of calories in the meal, implying that calorie posting led to more informed decision-making. There was no impact on enjoyment of the meal. The eye-tracking data suggested that the spatial arrangement altered individuals' search strategies while viewing the menu. This research suggests that the spatial location of calories on menus may be an important consideration when designing calorie posting legislation and policy.

Keywords: Attention; Eye-Tracking; Food Choice; Spatial; Calorie Posting

1. Introduction

Calorie posting – putting information about the number of calories in each dish on menus – is the focus of rigorous debate between regulators, policymakers, consumers and the restaurant industry across many, particularly Western, countries. The United States mandated calorie posting in all chain restaurants with 20 or more locations in 2018 (FDA, 2018). Some European countries, including the United Kingdom and the Republic of Ireland, have voluntary calorie posting policies in place that are likely soon to be replaced by mandatory legislation (Department of Health and Social Care, 2018; Healthy Ireland, 2016).

Evidence is mixed as to whether calorie posting constitutes a useful tool for combatting obesity (Crockett et al., 2018; Fernandes et al., 2016; Hillier-Brown et al., 2017; Kiszko, Martinez, Abrams, & Elbel, 2014; Littlewood, Lourenço, Iversen, & Hansen, 2016; Sacco, Lillico, Chen, & Hobin, 2017; Sarink et al., 2016). Some reviews and meta-analyses conclude that calorie posting may persuade consumers to choose lower calorie options, but individual studies differ and many are of insufficient quality to generate strong conclusions (Crockett et al., 2018; Fernandes et al., 2016; Hillier-Brown et al., 2017; Littlewood et al., 2016; Sacco et al., 2017; Sarink et al., 2016). Concerns centre on experimental biases, especially regarding hypothetical decisions, experimenter demand and lack of ecological validity. Furthermore, the format of calorie information varies widely across studies.

This latter observation points to a gap in this public health literature. Calorie posting is titled a "salience nudge" – information made salient at the point of decision (Thunström, 2019). As Taylor and Thompson (1982) defined it "salience refers to the phenomenon that when one's attention is differentially directed to one portion of the environment rather than to others, the information contained in that portion will receive disproportionate weighting in subsequent judgments" (p.175). The placement of information can significantly alter its impact. Yet how the placement of calorie information on menus affects the attention it receives remains unknown.

The present experiment manipulated the spatial location of calorie labels on menus. Our "lab-in the-field" design allowed us to study real food choices of people who were unaware that their choices were being studied, while nevertheless tracking their eye movements – a combination not obtained by previous research. We measured choice, consumption, knowledge, satisfaction and attention. Furthermore, the spatial arrangements of price and calorie information tested were endorsed in advance by legislators, who confirmed that they provided a plausible basis for enforceable regulations in the restaurant sector. Before describing the experiment in detail, we consider relevant previous research and explain how our hypotheses were generated.

1.1. Spatial Location, Attention and Order Effects

The placement of information can alter its impact. For example, individuals are twice as likely to read and act on product warnings if they are placed within a “Directions for Use” rather than a “Precautions” section (Edworthy et al., 2004; Frantz, 1993). This suggests that decision-making is affected not just by the information received but by when that information is processed. Formats of non-food ingredient labels that make it easier to search can improve comprehension and attention (Yazar, Seimyr, Novak, White, & Lidén, 2014). Consumers are more likely to view labels on cigarette packets or food packaging when they are placed at the top or centre of their visual field compared to the bottom (Graham, Orquin, & Visschers, 2012; Hwang et al., 2018). The salience of nutritional labels can drive attention to the information and predicts subsequent healthier – albeit hypothetical – choices (Bialkova et al., 2014; Crosetto, Muller, & Ruffieux, 2016). In a more extreme illustration of the point, a recent field trial found large effects on sales of calorie-dense muffins compared to calorie-light scones when calories were presented in a font size ten times larger than the price at the point of purchase (Nikolaou, McPartland, Demkova, & Lean, 2017). The authors conclude that where calorie labelling is introduced the information should be prominent and larger than the price, making the point that health warnings on other products, such as cigarettes, are often displayed on at least 30% of the packaging (Nikolaou et al., 2017).

Such links between salience, attention and choice are consistent with decision-making models such as the attentional drift-diffusion model (aDDM). The model has not yet been applied to the area of calorie posting. According to the aDDM, the longer an individual looks at an option, the more evidence they accumulate for it and the more likely they are to choose it (Krajbich, Armel, & Rangel, 2010; Krajbich, Lu, Camerer, & Rangel, 2012). Later versions of the aDDM cover multi-attribute choices, supported by evidence that paying more attention to specific attributes increases the weight given to those attributes in the decision (Fisher, 2017). If bottom-up attention is driven by the salience of information, then placing calorie information in a location that attracts more attention may increase the likelihood that individuals choose lower calorie options.

1.2. Spatial Location of Calories in the Literature

A recent Cochrane review concluded that putting nutritional information on menus leads to an average reduction in purchase and consumption per meal of about 8% (Crockett et al., 2018). However, effect sizes vary from none to very large. If the spatial location of calories alters salience then differences in menu layout could partly explain the diversity of findings. Of the 13 studies reviewed, we ascertained the menu layout of 10. Of these, two had signs above individual items and one had arrows pointing to low calorie options (Allan, Johnston, & Campbell, 2015; Dubbert, Johnson, Schlundt, & Montague, 1984). Four had nutritional information to the left of the price, one above menu items, one below menu items, one to the right of the description and another on the right but within descriptive text (Ellison, Lusk, & Davis, 2013, 2014; Girz, Polivy, Herman, & Lee, 2011; Hammond, Goodman, Hanning, & Daniel, 2013; Harnack et al., 2008; Holmes, Serrano, Machin, Duetsch, & Davis, 2013; Platkin et al., 2014). The menus varied in visual complexity associated with additional information and pictures. One study placed lower calorie options to the left of a point-of-purchase sign (Allan et al., 2015). The authors hypothesised that items on the left would attract more attention, as previous research has found an attentional bias towards the left visual field. However, they tested only presence versus absence of the sign, not whether effects differed when the spatial location was reversed.

The above is not intended as a comprehensive list of all of the spatial locations and formats that have been used in the field. Rather, it indicates important variance that occurs across individual studies, which may not be accounted for when summarising evidence for or against calorie posting.

We know of only one study that directly tested differences in the spatial location of calorie posting on menus. Dallas, Liu, and Ubel (2019) hypothesised that participants would order lower calorie options when calories were placed to the left of food descriptions, based on two previous findings: 1) consumers are more likely to select healthy food when it is placed on the left rather than the right; 2) information received earlier is attended to and remembered better than information received later. Consistent with the hypothesis, individuals tended to order fewer calories when calories were displayed to the left of the food description rather than beside the price. Furthermore, the effect reversed when calories were placed on the far right of a menu for Hebrew speakers, consistent with the idea that the decision was affected by the order in which the information was read. However, decisions in these experiments were either hypothetical or decision-makers knew that they were participating in a food-choice study. Reading the calorie information earlier may have influenced participants' perceptions of what was expected of them or their desire to appear virtuous, i.e. increased experimenter demand. Work on "hypothetical bias" shows that hypothetical decisions can depart from real ones, including food choices (Aoki, Shen, & Saijo, 2010).

Dallas et al.'s (2019) study was published after we had pre-registered our hypotheses and collected our data. Our hypothesis was similar but the spatial locations we test are somewhat different. We hypothesised that calorie information placed between the food description and the price would be more likely to draw attention and therefore to influence choice. We theorised that as our English-speaking participants read from left to right, their gaze would need to pass through the calorie information to read the price. Consistent with the aDDM and previous findings (Bialkova et al., 2014), greater attention paid to calorie information would increase its weight in the decision. By contrast, if calorie information was displayed at the start or end, it might be easier to screen out. Observing real-time attention via eye-tracking would also allow us to assess where participants looked, when they looked at specific information, and how this related to their decision.

1.4 Study Motivation

The study had two main motivations. First, it was designed to pre-test possible regulations. The Irish government plans to introduce calorie information on restaurant menus (Healthy Ireland, 2016). During the design phase, we met Department of Health officials and sectoral stakeholders, including officers likely to enforce new regulations. Spatial location was approved as an element that could be incorporated into enforceable regulations should it prove important. Similarly, legislators sought evidence regarding the presence or absence on the menu of information about an adult's "recommended daily allowance" (RDA) of calories. Given previous research on salience, it was decided that calorie information should appear in the same font and size as the price. Second, we wanted not only to test "what works", but to gain insights into the decision-making mechanisms behind any differences in choices. Since spatial location was to be varied, we wanted to observe consumers' eye-movements. This presented a challenge, since we also wanted decisions to be real, not hypothetical. The challenge was met by employing a "lab-in-the-field" experiment. Participants chose lunch from a menu immediately after completing an unrelated experimental study in which their eyes were being tracked. A manipulation check – in which participants were asked what they thought the aim of the study was – revealed that only one participant realised that their choice of lunch was part of the study. This is important: choices were real and unlikely to have been influenced by experimenter demand. The design also allowed us to measure not just how many calories were ordered but also to approximate how many were actually consumed – the variable of primary importance if reducing calorie consumption is the aim of calorie posting.

We made the following pre-registered hypotheses (aspredicted.org #11685):

1) Participants who see calories and RDAs on the menu will be more likely to look at calories, order fewer calories, consume fewer calories and be more accurate in estimating the number of calories in their meal and RDAs.

2) Participants who see calories to the left of the price, compared to participants who see calories on the right, will be more likely to look at calories, order fewer calories, consume fewer calories and be more accurate in estimating the number of calories in their meal and RDAs.

In addition to these directional hypotheses, given the lack of previous research on the spatial location of calorie information and the variation in spatial location across different menu formats in previous studies, any associated differences in consumer attention to the menu would be of interest.

2. Methods

2.1. Participants

Participants (N=145) were recruited by a market research company. The sample was balanced by age, gender and working status to be approximately representative of Dublin, where the study took place. Three participants declined to order lunch, leaving a total sample of 142. The use of real consumers was important. Previous research has mostly used convenience samples of students, who are likely to have higher educational attainment than the general population – a factor associated with use and awareness of calorie posting (Green, Brown, & Ohri-Vachaspati, 2015).

We pre-registered our intention to collect data on a sample of 120-135 participants. The range was necessary as prior research suggested eye-tracking data would be lost for some participants due to anatomical differences or inability to track. As we also lost data for some participants who moved their heads while choosing their lunch (and thus could not be tracked) and for the three participants who did not order lunch, we increased the sample size to 145 during the data collection phase and before any analyses had been carried out. A power calculation for comparison of means in 3 independent groups with effect sizes ranging from medium to large suggested a sample size of between 40-50 per group. The final sample size of N = 142 was determined to be sufficient while also accounting for time and budget constraints. This allowed for 46-48 participants per group to test the spatial location (control vs. calories left vs. calories right) and RDA (control vs. calories without RDA vs. calories with RDA) effects.

2.2. Analysis Plan

We pre-registered our analysis plan (see aspredicted.org #11685) prior to collecting data. We planned to carry out regression analyses with number of calories ordered and consumed, accuracy of recall of calorie information and number of fixations to calorie information as dependent variables. We specified control variables of age, gender, educational attainment and day of the week.

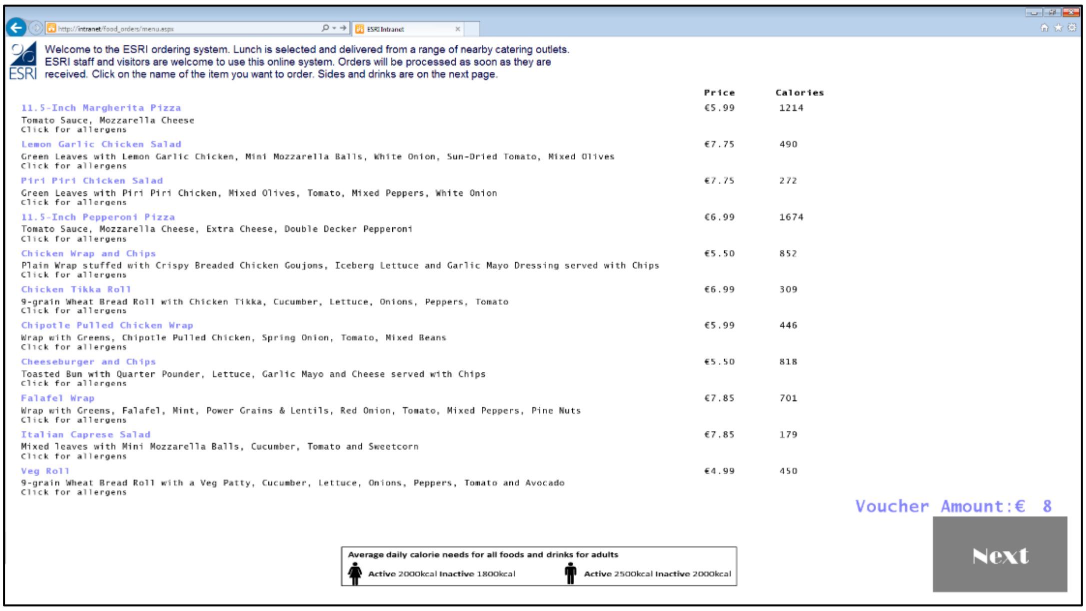
2.3. Materials

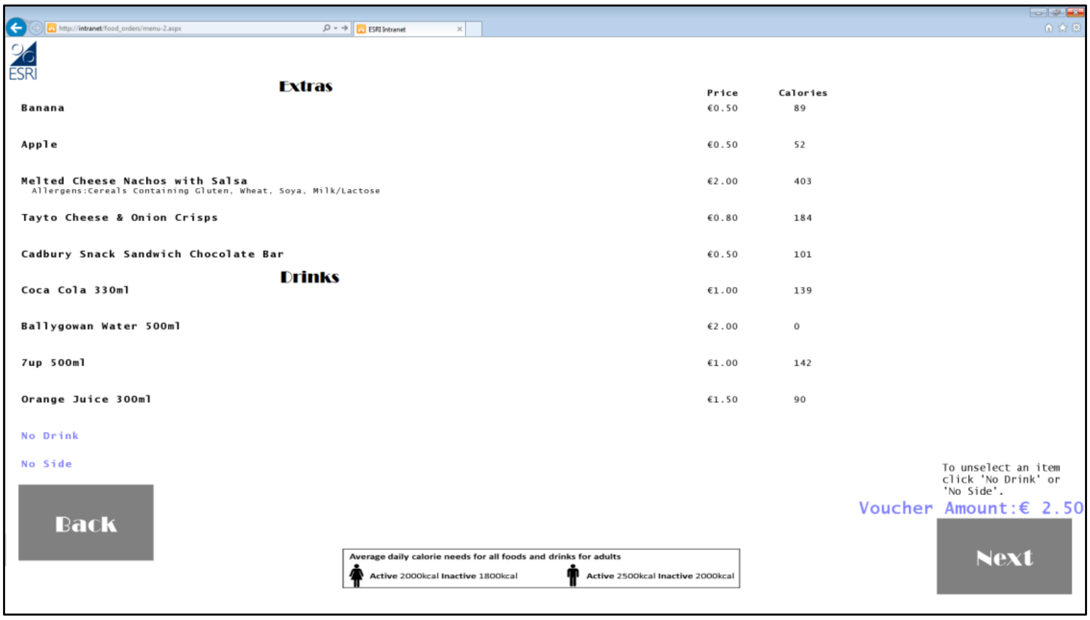
2.3.1. Menus

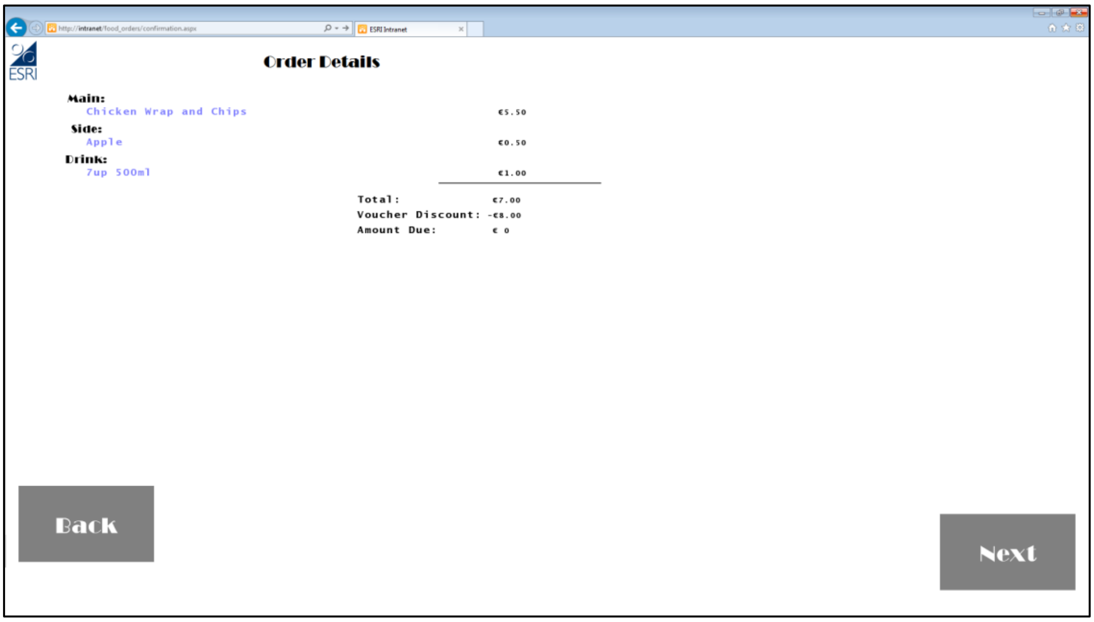
Food was sourced from outlets close to the researchers' institute. Three outlets were chosen that provided calorie information on their websites. The items covered sandwiches, salads, wraps, pizzas, burgers, fries, hot nachos, chips, chocolate, fruit, soft drinks, fruit juices and water.

The menu looked like an online ordering system with three pages: main courses, extras and confirmation (Figure 1). Participants could move freely between pages until they confirmed their order. Participants were randomly assigned to see one of five menus: Control (no calories or RDA); calories to the left of the price without RDA; calories left with RDA; calories right without RDA and calories right with RDA. Spatial location of calories and presence of RDA were orthogonally manipulated so that categories could be collapsed.

Figure 1. Screenshots showing an example of each of the three pages of the menu that participants in the Calories Right with RDA condition saw.







All participants saw the same items but the order was randomised. We did not include the names or branding of the outlets on the menu. Participants were aware of the source when it arrived, as the outlets used branded food wrapping. The price for each item was displayed to the far right of the page on the same horizontal line as the item description. When calories were present they appeared in a separate column either to the left or to the right of the price. In RDA conditions, the RDA for physically active and physically inactive men and women appeared at the bottom of the screen (Department of Health, 2016).

Although participants were receiving a free lunch, it was important for ecological validity that they had to consider price. Participants were told that they had been allocated €8 for lunch. This amount appeared at the bottom of the first page (i.e. "Voucher Amount: €8") and updated as items were added. Main courses were all less than €8 (€5.50 to €7.85) meaning that participants could order any main course, but may or may not then be able to order a side and/or drink, which ranged in price from €0.50 to €2.00. Thus, participants had to trade off preferences for items against prices. They were not reimbursed if they spent less than the allocated €8, nor could they purchase additional items with their own money.[1]

Main course items covered vegetarian (4) and non-vegetarian (7) options. The menu contained low (5 items, 179 – 490 calories) and high calorie options (6 items, 701 – 1674 calories). Price and calories were balanced, with 2 low calorie-low price options, 4 low calorie-high price options, 3 high calorie-low price options and 2 high calorie-high price options. All participants saw the same prices and calories. Sides and drinks were a mixture of healthy and unhealthy, sweet and savoury options that ranged from 0 to 403 calories.

Menu item descriptions, price and calorie information were all written in black text in size 16 font of type Lucida Sans Typewriter.

We recorded what participants ordered and the number of calories in each item. Food was weighed before being given to participants and the remains were weighed after, giving an approximation of the number of calories consumed.

2.3.2. Questionnaire

Manipulation Check

Participants were asked to indicate what they thought was the purpose of the studies they had participated in. They were given a free form text box in which they could type their answers and were given the following instructions: "We are interested in your experience of participating today. What do you think was the purpose of the studies you took part in?" Participants could read over and confirm their answer before submitting.

Decision Information

Participants completed a series of questions on their food decision and meal satisfaction. They were given the following instructions: "We are interested in how people make everyday decisions. We

[1] A coding error meant that the 9 people who ordered the chicken tikka wrap were able to spend more than €8. Seven of these participants ordered a drink or side which meant they spent between €8.79 and €9.99. These participants were spread throughout the conditions (N= 3 in control, N = 2 in calories left and N = 2 on calories right). The mean spend for the other 135 participants was €7.40 (SD = 0.65, range €5.49 - €8).

would now like to ask you some questions about your lunch decision today, about your understanding of recommended daily guidelines and about what information you look for on a menu.” Participants were given a 7-point rating scale that had written labels on the first (“Not at all happy”), fourth (“Neither happy nor unhappy”) and seventh (“Very happy”) points. Participants were also asked to rate, in order of importance, the factors that were important to them when choosing their lunch. The options were taste, nutritional value, price, calorie content and hunger/lack of hunger. Participants could select any that applied and in any order. The order that the options appeared in was randomised across participants.

Nutritional Knowledge

Participants estimated the number of calories in their main course, side and drink. They were given the following pre-amble: “In the following questions we will ask you to estimate how many calories were in the main, side and drink that you chose today.” They were then given a text box from which they could type in their answer to the questions: "How many calories would you estimate were in your main course? Type your best guess and then hit Enter”; “How many calories would you estimate were in your side (if one chosen)? Type your best guess and then hit Enter”; and “How many calories would you estimate were in your drink (if one chosen)? Type your best guess and then hit Enter.” They also estimated the RDA of calories for physically active and non-physically active men and women in response to the following question “What is the recommended daily allowance of calories for a (non)-physically active male (female)? If you don't know please still enter your best guess." Participants were asked to confirm their answer after each question and could change if they had made a mistake or wanted to amend it.

Background Characteristics

We recorded participants’ age, gender, educational attainment and whether they were vegetarian. Only five were vegetarian, divided between control (N=2), calories left (N=2) and calories right (N=1).

2.3.3. Eye-tracking

Participants sat before a 1920 mm x 1080 mm computer screen connected to an EyeLink 1000 Plus (SR Research, Ontario). We used a 25mm high speed lens for remote tracking with a sampling rate of 1000 Hz and a typical accuracy of 0.25 – 0.50°. We did not use a chin rest as this would necessitate telling participants to keep their head on the chin rest while choosing their lunch, which might reveal the study aims. Instead, we enabled “remote mode”, whereby participants put a bulls-eye target sticker in the centre of their forehead. The distance from target to camera was the recommended 600 mm.

We determined Areas of Interest (AOIs) for prices, calories and the RDA box. Calories and prices AOIs were non-overlapping rectangular boxes of 400 pixels (80 pixels x 50 pixels). The RDA AOI was defined as a 734 pixel x 105 pixel rectangle covering the whole area of the RDA box.

Participants were calibrated prior to the first (non-food related) task using 13 calibration points on a background that was the same shade as the menu.

2.4. Procedure

Participants came to the researchers' institute to undertake a series of real consumer decision-making studies on weekdays between 11:30 and 14:30. They understood that they would attend for approximately 90 minutes and would receive compensation of €40 plus lunch. They did not know that the aim of the study was to assess lunch choices.

On arrival each participant was told that there were three parts, with breaks. The first task involved choosing between pairs of (non-food) products on screen while eye movements were tracked. This task was a real but unrelated study which meant we could calibrate the eye tracker for participants without revealing the aims of the current study. When the participant got to the final trial, the experimenter left the room and told the participant to order their lunch using the online system at their leisure. The aim was to avoid experimenter demand effects. Experimenters were blind to the condition participants were assigned to. At the end of the task, participants were directed via a hyperlink to an online ordering system. Meanwhile, the eye tracker remained running.

Once the participant had ordered, the experimenter re-entered and brought them to the second task. This was also a real study unrelated to food choice. While the participant completed this, the experimenters ordered the food, then weighed all items before delivering to the participant. Lunch was eaten approximately 30 minutes after ordering. The participant was left alone to eat and told to let the experimenter know when they were ready to continue.

After eating, participants completed the questionnaire. They were then debriefed. They were given a retrospective consent form to confirm that they were happy for the experimenters to retain their data, including the lunch order. The form reiterated that they could withdraw at any time. No participant withdrew their data at any stage. After the participant had left, the food remains were weighed again.

The study received ethical approval from the institute's ethical review committee.

3. Results

There were no statistically significant differences in background characteristics between conditions (Table 1).

Table 1. Demographics by condition

	Control	Calories left no RDA	Calories left + RDA	Calories right no RDA	Calories right + RDA	Test of statistical significance
Age (SD, range)	40.49 (15.92) 18-70	39.87 (12.97) 19-59	36.21 (12.65) 18-68	41.5 (15.50) 18-71	39.52 (13.80) 19-66	$\chi^2(4)=1.78$, $p = .78$
Education (% degree+)	28.26%	43.48%	41.67%	50%	34.78%	$\chi^2(4)=3.73$, $p = .44$
Male	57.45%	60.87%	37.50%	50%	43.48%	$\chi^2(4)=3.96$, $p = .41$
N	48	24	24	23	23	

Note. Statistical significance was tested using a Kruskal-Wallis test for age and Pearson chi-square tests for education and gender.

3.1. Manipulation Check

All but one participant was unaware that their lunch choice was part of the study until they were debriefed.

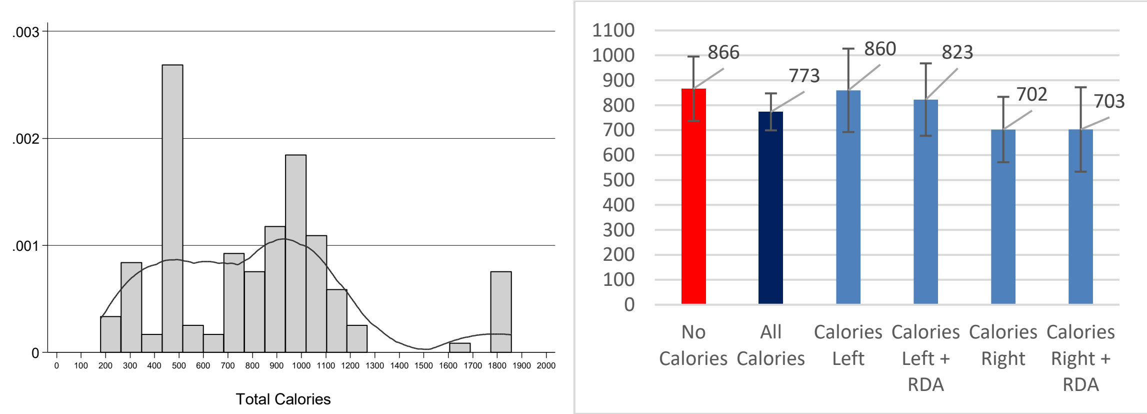
3.2. Items Ordered

Participants ordered 54 different combinations of main courses, sides and drinks; no one combination dominated (Supplementary Material).

3.3. Calories Ordered

We calculated calories ordered as total number of calories including main course, side and drinks (if ordered). The average was 805 (SD = 393, range 179 – 1858). Participants who saw calories ordered an average of 93 (11%) fewer calories than controls. Participants in all calorie conditions ordered fewer calories than controls (for all means and 95% confidence intervals see Figure 2). We had hypothesised that the spatial position of calorie information would be important and we found this effect but, contrary to our hypothesis, participants who saw calories on the right ordered the fewest calories with an average of 163 (19%) fewer than control.

Figure 2. Total calories in the meals that participants ordered overall and by condition



Note. The second bar is an average of the four bars that follow it. Error bars are 95% confidence intervals.

Testing robustly for statistical significance is not straightforward, because the distribution was non-normal and possibly tri-modal (Figure 2).[2] Our analysis strategy was to recode the dependent variable into three categories and to estimate ordered logistic regression models. Visual inspection implies three overlapping distributions, <600 calories, 600-1500 calories and 1500+. This first cut-off of 600 calories is in line with the most recent public health recommendations and the Cochrane review for lunchtime meals (Crockett et al., 2018; Robinson, Jones, Whitelock, Mead, & Haynes, 2018). As only 10 participants ordered more than 1500 calories we considered the highest category to be anything over 1000 calories, i.e. beyond the second peak. We then ran sensitivity analyses for robustness.

Three ordered logistic regressions confirm that participants who saw calories to the right of the price ordered fewer calories compared to controls (Table 2). A Wald test for equality of coefficients between the left versus right conditions showed some evidence for difference, ($\chi^2(1) = 3.38$, $p = .066$, two-tailed).

All models satisfy a Brant test of the proportional odds assumption. Rerunning the analysis with 1500 calories as the higher cut point strengthens all effects, but given the small number of people in the highest group, we opt for the more conservative 1000 cut point. Linear regressions (OLS) with calories as a continuous dependent variable show the same patterns but, as expected, the assumption of normally distributed residuals does not hold. Although assignment to groups was random, we added control variables for age, gender, educational attainment and day-of-the-week. Age was statistically significant ($\beta = -.03$, $SE = .01$, $p = .016$, two-tailed), with older adults less likely to be in the medium or

[2] Previous studies do not standardly report the distribution of calories ordered, despite the likelihood of non-normality. This is arguably a concern for the empirical literature on calorie posting, given the distribution shape we report here.

high calorie categories. The main effect of calories displayed on the right remained statistically significant (β = -.69, SE = .41, *p* = .045, one-tailed).

Table 2. Ordered logistic models showing effect of condition on level (low, medium, high) of calories ordered

Dependent Variable: Calories ordered	(1)	(2)	(3)
Calories left	-.05 (.38)		
Calories right	-.77 (.39)*		
Calories no RDA		-.25 (.38)	
Calories + RDA		-.55 (.39)	
Calories left no RDA			.15 (.46)
Calories left + RDA			-.27 (.47)
Calories right no RDA			-.68 (.47)
Calories right + RDA			-.87 (.49)*
N	142	142	142

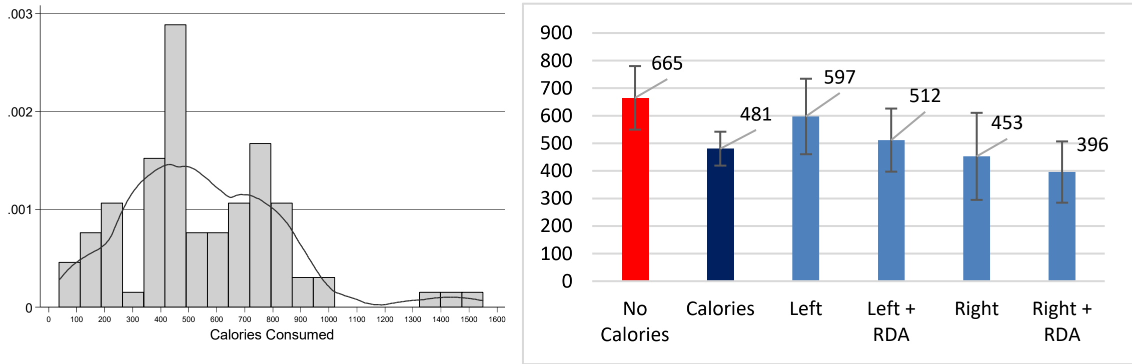
p* < .05, ***p* < .01, * *p* < .001. All tests are one-tailed.
Note. Breakdown of experimental manipulation in three ways: (1).control vs. calories left (+/- RDA).vs. calories right (+/- RDA); (2).control vs. calories without RDA vs. calories with RDA; (3).control vs. all conditions. Coefficients with standard errors.

3.4. Calories Consumed

It is important also to examine calories consumed, as it is possible that those who ordered fewer calories might have eaten more of what they ordered. We estimated the number of calories consumed from the proportion of food eaten (in grams). We could not estimate calories consumed for a minority who took some food or drink away with them. Previous studies that have included this measure have told participants that for the purposes of the study they must not take food with them. We did not do this to avoid revelation of the study aims and experimenter demand; our consumption measure reflects participants' own choices. We were nevertheless able to estimate the calories consumed in the main course for 113 participants and across all items for 87 participants. Unsurprisingly, participants who took food away were more likely to have ordered a side or drink and, hence, more calories (M = 875, SD = 390 versus M = 760, SD = 390). Availability of the measure was unrelated to condition or demographics.

By weight, the mean proportion of food consumed relative to food ordered was 0.75. This differed little across conditions and was in fact marginally (but non-significantly) lower when calories were displayed. The average number of calories consumed was 551 (SD = 280, range 37 – 1550). Participants who saw calories consumed an average of 184 calories fewer than controls. Again we found the difference was stronger for those who saw calories on the right (for all means and 95% confidence intervals see Figure 3). The distribution of calories consumed was non-normal and, again, visual inspection suggested tri-modality (Figure 3). We split the measure into three categories: low (< 400), medium (400-699) and high (>700). Three models that test for an effect of condition confirm a statistically significant reduction in calories consumed when calories were displayed on the right (Table 3). A test for equality of coefficients finds a statistically significant reduction in calories consumed for right versus left, $\chi^2(1)= 4.82$, $p = .028$, two-tailed.

Figure 3. Total calories in the meals that participants consumed by condition



Note. The second bar is an average of the four bars that follow it. Error bars are 95% confidence intervals.

All models meet the proportional odds assumption. Equivalent OLS models generate a stronger pattern of results but non-normal residuals. Repeating the analysis for calories consumed in only the main course (N = 113) generates similar results. Including age, gender, educational attainment and day-of-the-week leaves the main effects unchanged. There was a negative effect of age on calories consumed and a positive effect of Thursdays.

Table 3. Ordered logistic models showing effect of condition on level (low, medium high) of calories consumed.

Dependent Variable: Calories consumed	(4)	(5)	(6)
Calories left	-.28 (.49)		
Calories right	-1.42 (.51)**		
Calories no RDA		-.98 (.52)*	
Calories + RDA		-.72 (.47)	
Calories left no RDA			-.24 (.63)
Calories left + RDA			-.31 (.59)
Calories right no RDA			-1.91 (.70)**
Calories right + RDA			-1.13 (.58)*
N	87	87	87

*$p < .05$, **$p < .01$, *** $p < .001$. All tests are one-tailed.
Note. Breakdown of experimental manipulation in three ways: (1).control vs. calories left (+/- RDA).vs. calories right (+/- RDA); (2).control vs. calories without RDA vs. calories with RDA; (3).control vs. all conditions. Coefficients with standard errors.

3.5. Nutritional Knowledge

Participants underestimated the calories in their main course by an average of 193 calories (SD = 419) and in their total meal by 178 calories (SD = 501) (Figure S1). Underestimation was less in all conditions in which calories were displayed. Accuracy was best when calories appeared on the right (Supplementary Material).

We ran a bootstrapped mediation analysis to test whether accuracy mediates the effect of spatial location on calories ordered and consumed (Preacher & Hayes, 2004). This analysis shows a full mediation effect with a statistically significant indirect effect of accuracy on calories ordered (β = -0.10, SE = 0.04, 95% CI -0.17, -0.03) and consumed (β = -0.10, SE = 0.05, 95% CI -0.21, -0.02) (Table S2). This suggests that the effects of calorie posting were mediated by consumers' knowledge of the calorific content of what they order and eat.

3.6. Other variables

Participants underestimated RDAs on average but the range was wide indicating a general lack of knowledge. This is in line with previous survey research which found that almost half of consumers could not guess how many calories they should eat in a typical day and, of those who suggested they did know, only 29% answered within the correct bracket of 1500-2500 (Safefood, 2004). Putting calories on the menu slightly increased accuracy but putting actual RDA on the menu had little, if any, additional effect. Participants in the calorie conditions reported giving a greater weight to calories in their decision but there was no difference by spatial location. Putting calories on menus did not reduce enjoyment of the meal (Supplementary Material).

3.7. Eye Movements while Viewing the Menu

As is standard in eye-tracking studies, thick glasses or anatomical differences disrupted tracking for a minority of participants (N = 18) – a failure rate consistent with previous studies (Stewart, Hermens, & Matthews, 2016). As we did not restrain participants' heads, some moved their seating position when choosing lunch, which meant that tracking data was lost. Ultimately, we obtained good data for 100 participants. This subsample had somewhat higher educational attainment (42% with degree versus 27% for non-tracked participants) and was younger (mean 37.8 versus 44.1). Seventy-four saw calories on the menu – 35 on the left and 39 on the right.

3.7.1. Attention by Spatial Location of Calories

We hypothesised that calories to the left of the price would attract greater attention and thus have a stronger effect on choice. In addition, although not part of our original hypothesis, we were able to test the theory proposed by Dallas et al. (2019) that the spatial location of calories influences how early individuals view calories and that early viewing increases the weight given in the decision.

Contrary to our hypothesis that participants would spend more time viewing calories when they were to the left of the price, there was no difference in the log number of fixations or dwell time between calorie conditions (β = .14, SE = .22, p = .26; β = .43, SE = .48, p = .19 (one-tailed)).

As the spatial location of calories was not associated with fixations to calories we did not carry out the planned mediation analysis. However we did test whether attention paid to calorie information resulted in fewer calories being ordered and consumed, accuracy of calories estimated and greater self-reported weight given to calories in the decision. All estimated coefficients are in the hypothesised direction and three of the four tests are statistically significant – only the effect on calories consumed is non-significant, although the estimated coefficient is similar to that for calories ordered (Table 4). We found similar relationships for number of calorie labels viewed and dwell time.

Table 4. Ordered logistic models showing relationship between fixations to calories labels and calories ordered, consumed, estimated and weighted.

Dependent Variables	Calories Ordered	Calories Consumed	Inaccuracy of Calories Estimated	Calories Weighting
Fixations to calorie labels	-.41 (.24)*	-.39 (.33)	-.71 (.26)***	.59 (.23)**
N	74	45	74	74

*p < .05, **p < .01, *** p < .001. All test are one-tailed.
Note. For calories ordered, consumed and estimated higher categories indicate more calories and greater inaccuracy. For calorie weighting higher scores indicate a reported greater weighting of calorie information in the decision. Coefficients with standard errors.

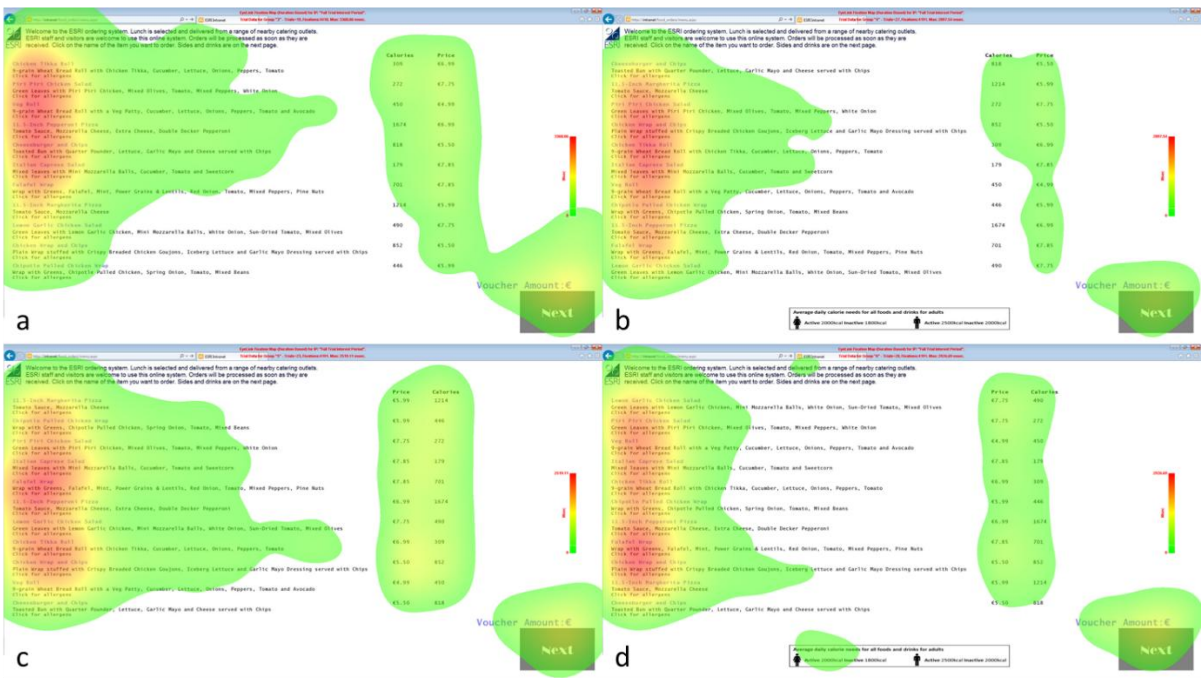
That spatial location did not influence attention, but attention did influence behaviour, might suggest that attention paid to calorie information was driven by top-down processing – participants actively seeking out calorie information as part of a decision strategy – rather than bottom-up processing driven by salience. We return to this idea later.

Consistent with reading from left to right, participants viewed calories earlier when they were placed on the left (M = 13.48 seconds, SD = 22.75, median = 4.78 seconds, 95% CI = 5.28 – 21.69 seconds) than the right (M = 22.40 seconds, SD = 19.64, median = 18.49 seconds, 95% CI = 15.85 – 28.95 seconds), Z = -3.08, p = .002. This is a clear rejection of the primacy hypothesis which would suggest that participants who saw calories on the left would order and eat fewer calories because they viewed calorie information earlier (Dallas et al., 2019). We observed the opposite. We tested whether participants who saw calories earlier ordered fewer calories, ate fewer calories, estimated meal calories more accurately or gave greater self-reported decision weight. No effects were significant.

An alternative possibility is that rather than altering the amount of attention paid to calories, the spatial location changed individuals' search strategy. The attentional drift diffusion model and primacy hypothesis assume that attention is a bottom-up process driven by external factors. In the next analyses we consider whether spatial location influenced search strategies.

Figure 4 presents colour-coded heat maps of the average dwell time for each of the four calorie conditions. They suggest that the extent to which participants continued to look at calorie information differed between conditions. This was not an original hypothesis, so these results should be considered exploratory. We ran three additional analyses to check for differential top-down strategies between conditions. We tested whether there were differences in: (i) the proportion of calories to prices viewed, which would indicate whether the participant looked at the calories of an option being considered, regardless of how many options they entertained; (ii) the content of calorie information viewed, which would indicate searching for lower or higher calorie options; (iii) where participants looked immediately after viewing calorie information, which might indicate a desire to compare calories directly between options.

Figure 4. Colour-coded heat maps of average dwell time by condition



Note. Letters refer to conditions: a = calories left without RDA; b = calories left with RDA; c = calories right without RDA; d = calories right with RDA.

Proportion of Calories to Prices

Participants in the calories left condition viewed an average of two-thirds of the number of calorie labels to price labels on the main menu (M = 0.69, SD = 0.69, 95% CI = 0.46 - 0.93). When calories were displayed to the right, this proportion equalised (M = 0.98, SD = 0.69, 95% CI = 0.75 – 1.21), $Z = -2.45$, $p = .01$, two-tailed). We checked whether this held across the whole menu (main menu plus extras and drinks). The proportions were similar (M = 0.63, SD = 0.37, 95% CI = 0.50 – 0.75 vs. M = 0.89, SD = 0.82, 95% CI = 0.63 – 1.16) but the difference was not statistically significant, $Z = -1.51$, $p = .13$, two-tailed). This is possibly because fewer participants (N = 51) ordered sides and drinks and therefore many would not have considered prices or calories on this page.

Content of Calorie Information Viewed

There was no difference in whether participants viewed the calorie label of the main course they chose when it was on the right (67%) than when it was on the left (60%), $\chi^2(1)$.= 0.35, $p = .55$, two-tailed). But the main course labels viewed had, on average, a lower calorie content in the calories right (M = 599, SD = 156, 95% CI = 546 - 651) compared to calories left condition (M = 697, SD = 161, 95% CI = 639 - 755), $Z = 2.34$, $p = .02$, two-tailed). Consistent with this, the lowest calorie label viewed on the right was smaller than the lowest viewed on the left (M = 285, SD = 143; 95% CI = 237 - 332 versus M = 355, SD = 178, 95% CI = 291 - 419; $Z = 2.02$, $p = .04$, two-tailed). This pattern might indicate that when calories were on the right, some participants actively searched for a lower calorie option to compare.

Area of Menu Viewed after Calorie Fixation

Across all 73 tracked participants who saw calorie information, there were 880 fixations made to calorie labels. Of these, 30% (264) were followed by another fixation to a calorie label and 70% by a fixation to something else. This proportion was higher when calories were on the right (34.98%) compared to the left (24.4%). A multilevel logistic regression with condition as the independent variable and participant as a fixed effect confirmed this difference, $\beta = .62$ (.24), $p = .01$, two-tailed. Because sometimes multiple fixations were made to the same calorie label, we reran the analysis looking only at situations in which a participant moved their eyes away from the calorie label they were fixating. Again, the subsequent fixation was more likely to be to another calorie label if calories were on the right, $\beta = .77$ (.27), $p = .004$, two-tailed. This suggests that participants in the calories right condition may have engaged in a different search strategy in which they compared across different calorie labels.

3. Discussion

We manipulated the spatial location of calories on menus and observed real food decisions. When calorie information was displayed consumers ordered and consumed fewer calories, were more knowledgeable about the calories in their meal and were more likely to report that calories had influenced their decision. Consistent with our hypothesis we found a strong effect of spatial location but contrary to our hypothesis, calories placed to the right rather than the left of the price drove the effect. Exploratory eye-tracking analyses suggest that placing calories to the right may have altered participants' search strategy.

Previous findings in this area are conflicting. Revising the studies collated by the latest review revealed that the spatial position of labels on menus varied widely (Crockett et al., 2018). That spatial location alters consumers' choices may thus explain this heterogeneity. Since our study is the first to test this particular manipulation, it needs replication elsewhere. However, our effect was consistent across all outcome variables, including eye movement data. Furthermore, the only other study we know of that systematically manipulated spatial location also recorded differences, although most decisions were hypothetical, participants knew they were being observed and eye movements were not studied (Dallas et al., 2019).

Previous research has found that attention mediates the effect of nutrition labels on choice (Bialkova et al., 2014). We did not find differences in fixations or dwell time by spatial location, but we did find differences in decision strategies. When calories appeared on the right, participants tended to view lower calorie labels, to divide attention more equally between calories and price, and to compare across calorie labels. That is, the spatial location of calorie information may have altered the ongoing decision process.

Why was the effect larger for labels on the right of the price? We hypothesised that participants who saw calorie information closer to the centre of the menu, to the left of the price, would be more likely to attend to it and to weigh it in their decision. We offer two potential explanations for the contrasting effect that we observed: right visual field advantage and attribute ordering.

Presenting images in the left visual field is associated with higher activation of attention networks while presenting words in the right visual field increases processing speed and accuracy (Jordan & Paterson, 2009; Nicholls & Wood, 1998). We used text in our study. Thus, participants may have processed calorie information faster and more accurately when it was in the right visual field, increasing its influence on decisions. This could also explain why we observed no differences in fixations or dwell time, which need not be strongly correlated with processing. However, that placing calorie labels on the right altered the timing of viewing calorie information, the balance between looking at calorie and price information, and the likelihood of immediately fixating another calorie label are less obviously consistent with this account.

Another possibility is that displaying calories to the right matches the sequence in which participants tend to make food choices. People habitually weigh up the attractiveness of food descriptions against prices. Placing calories to the right of the price may retain the natural order of the decision while providing an additional factor, perhaps a final check on the desirability of the option. In keeping with this, participants in the calories left condition viewed calories earlier and before price. Over the course of the whole decision, however, when calories were on the right participants more evenly balanced viewing calorie and price information, and looked at lower calorie options. Thus, the decision process sequence may lead people to search calorie information more when it is on the right, even though they see it later. Previous eye-tracking research shows a bias towards the last option viewed, even when this is externally manipulated (Ghaffari & Fiedler, 2018).

How might this fit with Dallas et al. (2019)'s findings of a greater effect when calories are placed before the food description than after the food description and price? The layout of menus across the two studies differed. Our menus included calorie information in the same colour, font and size as the food description and price planned legislation is likely to mandate it. By contrast, the food description in Dallas et al.'s study was in a large, capitalised, bold font while the calorie information and price were in small, lower case, non-bold font. When calories were on the left, calorie information contrasted with the food description. When on the right, calorie information was within a body of similar text that included price and ingredients. Thus, the additional salience of the calorie information when placed beside the food description may have played a role. Similarly, we found that placing calorie information in the midst of other information reduced its influence.

Dallas et al.'s explanation for their results was that seeing calorie information earlier made it more influential. By contrast, our eye-tracking results suggest that it is not how early the information is viewed, but how it fits with the decision sequence that matters. If calorie information acts as a screening tool, then putting calories prominently at the edge of the other attributes – either at the start or the end – may facilitate individuals to use this check. This would be consistent with the findings of both studies.

The strength of this study is that it combined experimental control with ecological validity and a study of the decision process via eye-tracking. Only one consumer realised that their lunch choice was part of the study, thereby minimising experimenter demand. Our menus looked like an online ordering system and the food was from typical city catering outlets, including a large range of options in terms of both taste and calories. Price had to be factored in, enhancing ecological validity, although participants did not hand over money. Finally, we collected data on a large number of outcome variables including choice, consumption, accuracy and eye movements, allowing us to assess consistency of effects.

There are also some limitations. Our lab-in-the-field study while tracking eye movements required data to be collected one participant at a time rather than in groups, as would be possible in standard field trials. It took 2-3 months to collect the data and the resulting sample may not have conferred sufficient statistical power to detect some interesting effects. We collected eye-tracking data on 100 participants – a large sample by the standard of eye-tracking studies, but not field studies. Some loss of data was necessary to avoid revealing the study aims.

The context could, potentially, have changed some participants' eating habits. Participants were left alone to eat lunch but the setting was still unfamiliar to them. It is possible that participants may have felt they were being observed and, therefore, those who saw calories on the menu may have been more likely to leave some food unconsumed. However, only one participant out of 145 believed that their lunch choices were part of the study. Further, if participants in the control group were more inclined to believe that they were being observed than those who saw any calories then we should also have seen differences in consumption between the calories left condition and control instead of just the calories right condition. Because lunch was free, participants may not have ordered what they might normally. The €8 limit aimed to counteract this and, in fact, a large proportion of participants could have spent more money than they did (37% spent less than €7.50). The menu items covered a large range of calories (179 – 1674). These were real options taken from chain catering outlets, but it is possible that consumers may not see as wide a range within individual outlets. This may reduce the size of the effect in an individual outlet, but is unlikely to explain the differential effects of spatial position. We tried to make the online ordering system realistic, but this too could have affected decisions. Indeed, there is no guarantee that our findings for an online menu generalise to menus handed out or posted in restaurants and cafés, where other contextual factors could potentially dilute or strengthen the effects we observe. The eye-tracking data give us some confidence that the psychological mechanisms involved would not be different for online menus, but field studies that systematically test alternative spatial locations of calorie information are needed. These trade-offs were necessary for testing the main hypothesis in an experimentally controlled environment. Future research could test spatial location in a field trial. Finally, it is possible that those who consumed less in the study ate more later, although studies that have tracked post consumption have not seen this trend (Roberto, Larsen, Agnew, Baik, & Brownell, 2010).

This study, combined with the body of previous evidence, suggests that calorie posting has the potential to reduce calorific intake. However, our results also sound a note of caution: the effectiveness of labels is a more complex issue than it appears. We find relatively large differences in behaviour depending merely on the spatial location on the menu. Where calorie information is smaller, embedded within text, or placed in a different location, it may have little or no effect. This is an important consideration. Policymakers may wish to avoid excessive regulatory burdens, but they may need to include specifications about content, size, colour and position within relevant regulations. Our findings illustrate a need to make the specific format of calorie information a focus of further research and policy development.

Reducing calorific intake is vital to tackle obesity. Solutions to the obesity crisis will require collaboration across government, industry and the individual. We conclude that a promising way to reduce calorie intake is to present calorie labels on menus but, importantly, that the spatial location of these labels may strongly influence the likelihood of success.

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