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Do you like what you see? The role of first fixation and total fixation duration in consumer choice



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ABSTRACT

Although there has been recent growing interest in the associations between measures of visual attention and consumer choice, there is still uncertainty about the role of the first fixation in consumer choice and the factors that drive total fixation duration. The study aimed (1) to investigate the influence of the first fixation on consumer choice, and (2) to disentangle two factors driving total fixation duration, namely preference formation (the process of establishing a preference for one of the items of the choice set) and the decision goal (task instruction). Participants chose between two products while their eye movements were measured. To investigate the influence of first fixation location on choice, first fixation location was manipulated in half of the trials. To disentangle effects of preference formation and the decision goal, participants selected either the product they wanted, or the product they did not want. Our findings showed that manipulating the first fixation towards an alternative did not influence its likelihood of being chosen. Although total fixation duration was mainly determined by the decision goal, it was also influenced by preference formation. The results provide important implications for the interpretation of eye tracking results and in-store marketing.

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Introduction

It is generally known that a product has to be noticed on the shelf for it to have a chance of making it into the shopping basket. Consequently, commercial interest in the role of visual attention in consumer choice is growing.

Commonly reported measures of visual attention in consumer research are the location of the first fixation and also total fixation duration, which is the total duration of all fixations on a specific stimulus (Peschel & Orquin, 2013; Reisenberg, 2013). Factors influencing visual attention are commonly distinguished by bottom-up and top-down processes (Corbetta & Shulman, 2002). Bottom-up, or stimulus-oriented, attention refers to attention captured by visual saliency (e.g., color, contrast), surface size, visual clutter

and location. The effect of visual saliency on attentional capture in consumer choice situations is well established: visually more salient advertisements and news articles are looked at longer and are more likely to be fixated on first, compared to less visually salient alternatives (Lohse et al., 1997; Bialkova & Van Trijp, 2011; Navalpakkam, Kumar, Li, & Sivakumar, 2012; Orquin, Mueller-Loose, & Scholderer, 2013). Top-down, or goal-oriented, attention refers to the voluntary allocation of attention and causes people to direct their attention to the objects that are most informative for their current goal or task. Examples of top-down factors in consumer choice situations are influences of pre-existing preferences, personal goals (e.g., the goal to eat healthy) and task instruction (in market research) on visual attention (Corbetta & Shulman, 2002; Rayner, Miller, & Rotello, 2008).

Down-stream effects of visual attention on consumer choice have gained much interest recently (Orquin & Mueller-Loose, 2013). Down-stream effects refer to causal effects of visual attention on decision-making. For example, it has been shown that manipulating the fixation duration towards an alternative can increase its likelihood of being chosen (Armel, Beaumel, & Rangel, 2008; Shimojo, Simion, Shimojo, & Scheier, 2003). A recent

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review suggested that attention might influence choice by three potential mechanisms: (1) by a mere exposure effect, (2) by limiting the decision to fixated alternatives, and (3) by increasing the influence of fixated alternatives (Orquin & Mueller-Loose, 2013). However, a lot remains unclear about down-stream effects. For example, it has been repeatedly shown that people have a choice bias towards visually salient alternatives that are also likely to be looked at first. Yet, the causal effect of the first fixation location on consumer choice was never tested and is thus still unknown. Secondly, looking longer at chosen items (often referred to as ‘gaze bias’ (Schotter, Berry, McKenzie, & Rayner, 2010)) in consumer choice situations is often attributed to down-stream effects of fixation duration (i.e., gaze allocation that accompanies preference formation: the process of establishing a preference for one of the items of the choice set, Krajbich, Armel, & Rangel, 2010; Shimojo et al., 2003), while it might also be caused by processes of top-down attention, such as pre-existing preference or decision-goals (Orquin & Mueller-Loose, 2013).

In the present study we aim to clarify the role of the first fixation location in consumer choice and to explain how decision-goals and preference formation influence the gaze bias for chosen alternatives. The following sections will elaborate on these two issues.

The role of the first fixation in down-stream effects on consumer choice

Packages are designed to catch your eye. As previously mentioned, visual salience captures attention more readily: visually salient items are more likely to be looked at first and they are looked at longer (Lohse et al., 1997; Navalpakkam et al., 2012). It has been shown that choices can be influenced by manipulating visual characteristics of a package, such that it ‘pops out’ (e.g., Milosavljevic, Navalpakkam, Koch, & Rangel, 2012). However, it is unknown through which mechanisms this occurs. Whereas a higher visual saliency could result in a higher likelihood that the product is the first to catch the eye (location of first fixation), it could also retain attention to this item (i.e., longer total fixation duration) and thereby increase preference (Bialkova & van Trijp, 2011; Krajbich et al., 2010; Lohse, 1997; Navalpakkam et al., 2012; Orquin et al., 2013). Moreover, the visual manipulation itself (making a package brighter/darker) could also influence preference by increasing attractiveness (Van der Laan, De Ridder, Viergever, & Smeets, 2012). While down-stream effects of attention on choice can occur via fixation duration (Armel et al., 2008; Shimojo et al., 2003), much less is known about the role of the first fixation.

Multiple models of visual attention in decision-making suggest that the location of the first fixation plays an important role in the decision-process. Studies concerning the gaze cascade effect and down-stream effects of visual attention on decision-making (Armel et al., 2008; Shimojo et al., 2003), have suggested that gaze allocation both reflects and influences preference through preferential looking and mere exposure respectively. Therefore, an alternative that is first looked at has an initial advantage through the mere exposure effect (Simion & Shimojo, 2006). Evidence accumulation models (e.g., the drift diffusion model, Krajbich et al., 2010) assume that evidence in favor of an alternative is accumulated during fixations. The decision is made when the accumulated evidence passes a certain threshold towards one of the alternatives. Therefore, Krajbich and colleagues (2010) posit that the alternative looked at first should have an advantage over the other alternative because initially more evidence is accumulated. Orquin and Mueller-Loose (2013) propose that the first fixation itself might not influence preference for an item but that that fixations driven by visual salience might influence choice by the process of gate-keeping: visually salient items are more likely to attract fixations and to enter the consideration set (the items that are under consideration for choice), while less visually salient items fail to capture

attention and do not enter the consideration set and therefore are less likely to be chosen.

Although evidence accumulation models and the gaze cascade effect suggest an important role for the location of the first fixation, (i.e., the models predict that the alternative that is looked at first would be more likely to be chosen), empirical results on the association between first fixation and choice are mixed: some studies have shown that people are more likely to choose the item that they fixated on first (e.g., Glaholt & Reingold, 2011; Krajbich et al., 2010; Schotter et al., 2010) while other studies (e.g., Armel et al., 2008) have found no association between first fixation location and choice. Some authors have proposed that the location of the first fixation is influenced by top down effects of pre-existing preferences (e.g., for palatable high energy foods, Werthmann, Mogg, Bradley, & Jansen, 2011), while others posit that the location of the first fixation is mainly driven by factors that are uncorrelated with value, such as visual attributes (e.g., Bialkova & van Trijp, 2011; Lohse, 1997; Milosavljevic et al., 2012; Navalpakkam et al., 2012; Wolfe & Horowitz, 2004), the place on the shelf (Chandon, Hutchinson, Bradlow, & Young, 2009), cultural norms (e.g., reading from left to right, Krajbich et al., 2010), or a person’s decision goal (e.g., to identify the most effective versus the most liked advertisements, Rayner et al., 2008). Thus, it is unknown whether the first fixation indeed has a causal (down-stream) effect on choice, as the decision-making models described above would suggest.

To our knowledge no previous studies have experimentally investigated whether consumer choice can be influenced by manipulating the first fixation to a product. Therefore, our first aim was to investigate whether manipulating the first fixation towards an alternative increases its likelihood of being chosen. Investigating the influence of the first fixation on choice is relevant because it will elucidate how irrelevant cues (e.g., location on the shelf) can affect choices.

Disentangling the effects of decision goals and preference formation on the gaze bias for chosen alternatives

Several studies have shown that the ultimately chosen alternative is looked at longer (Atalay, Bodur, & Rasolofoarison, 2012; Chandon et al., 2009; Russo & Leclerc, 1994; Schotter et al., 2010). This phenomenon has been referred to as the ‘gaze bias’ (Schotter et al., 2010). The earlier mentioned models of visual attention in value-based decision making (Gaze cascade model, Shimojo et al., 2003; Simion & Shimojo, 2006; Evidence accumulation models, Krajbich et al., 2010) attribute the gaze bias towards chosen alternatives to a down-stream effect of fixation duration on choice, i.e., fixating longer on an alternative increases preference for it. These models attribute fixation duration solely to the build-up of preference or evidence for the stimulus that is fixated on. Preference formation is the process of establishing a preference for one of the items of the choice set. Basically, it involves establishing the value of the items in the choice set, and comparing them in order to reach a decision (e.g., Shimojo et al., 2003). The gaze bias for chosen alternatives is thought to reflect fixations accompanied by the process of preference formation. However, eventual selection of the item on which total fixation duration was longest is not specific for value-based decision making. It also occurs in perceptual decision making (Glaholt & Reingold, 2009a, 2009b, 2011), in which it is attributed to top-down factors such as the decision goals that results from a specific task instruction (e.g., Yarbus, 1967). For instance, when the decision goal is to indicate the roundest face from a range of faces, subjects look longer at the roundest face (Shimojo et al., 2003; Simion & Shimojo, 2006). Similarly, when the goal is to evaluate the healthiness of products, health logos are looked at longer (Orquin & Scholderer, 2011). Since it is not likely that total fixation duration is instigated by

value comparison in these perceptual decision making tasks, it can be questioned whether the gaze bias in value-based decisions can be attributed to fixation allocation accompanying preference formation or, alternatively, whether it is just a top-down effect resulting from the specific decision goal. Hence, the underlying causes of total fixation duration are unclear. We hypothesize that both the decision goal and preference formation will influence the total fixation duration during consumer choice.

A difficulty in disentangling the effect of the decision goal and the effect of preference formation on total fixation duration is that they usually concur when someone is asked to indicate the products he or she would prefer. However, negating the question enables disentangling these separate effects. Matching the products on pre-existing preference is crucial to rule out that the gaze bias for the preferred product is the result from top down effects of pre-existing preference on visual attention, rather than fixation allocation accompanying preference formation. By comparing the total fixation durations in the most-wanted decision type (“Which product do you want?”) and the least-wanted decision type (“Which product do you not want?”), we can infer whether fixation duration is influenced by preference formation, the decision goal, or both. If fixation duration would only be influenced by preference formation, we would expect that the most preferred option is always looked at longest, irrespective of choice type. However, if only the decision-goal would influence fixation duration, the most preferred option would be looked at longest in the most-wanted decision type and the least preferred option would be looked at longest in the least-wanted decision type. Fig. 1 shows the total fixation duration under the assumption that both the decision goal and preference formation influence total fixation duration in a binary choice between two products for which no difference in pre-existing preference exist. If the question is “Which product do you want to have?” (most-wanted decision type), the selected product is the product for which most preference was formed and the product is in line with the decision goal. Hence, both effects boost total fixation duration for the selected product. For the product that was not selected least preference was formed and it is not in line with the decision goal. Therefore, both effects diminish the total fixation duration for this product. Consequently,

there would be a large difference in total fixation duration between the selected and not selected product. If the question is “Which product do you not want to have?” (least wanted decision type), the effects of decision goal and preference formation counteract each other because least preference has formed for the selected product but it is in line with the decision goal. In contrast, for the not selected product more preference has been formed but the product is not in line with the decision goal. Consequently, a small or absent difference in total fixation duration between the selected and not selected product would be expected. Because we cannot predict the exact strength of the effects, confidence intervals are added in the figure depicting the hypothesized pattern of fixation duration (Fig. 1).

Disentangling effect of the decision-goal and the effect of preference formation on total fixation duration is relevant since total fixation duration in commercial eye tracking research is often used as a proxy for product preference, while this might not be a correct interpretation. Therefore, our second aim was to disentangle the effect of decision goal and the effect of preference formation on total fixation duration.

Material and methods

Participants

Twenty-three right-handed females (age in years: $M = 22.3$, $SD = 3.2$) with a normal body weight (BMI in kg/m^2 : $M = 21.4$, $SD = 1.5$) participated in the study. Participants were recruited by means of posters at the Utrecht University campus in The Netherlands. Exclusion criteria were being a smoker, being pregnant, having a food allergy, having a medically prescribed or slimming diet in the past six months, and having lost or gained more than five kg of bodyweight in the past 6 months. All participants had normal or corrected to normal vision. For one participant no eye tracking data could be acquired. This participant was excluded from all analyses, which resulted in 22 datasets.

Procedures

The study consisted of one study session of approximately 45 min in the afternoon (between 1 pm and 5 pm). Participants were instructed to refrain from eating and drinking (except for water) for 3 h before the session to ensure that food was a relevant stimulus. Upon arrival, the participants filled out an informed consent. The study was presented to the participants as a commercial study on snacks and cleaning agents that was conducted in cooperation with partners from industry. In order to simulate a realistic choice paradigm and to ensure task involvement, participants were told that they would actually receive one of the products they preferred. After the instruction, participants first indicated for all products the extent to which they wanted to have them. Participants did so by answering the question “How much do you want to have this product?” on a 9-point scale ranging from 1 = not at all, to 9 = very much. Subsequently, participants performed a product choice-task while their eye movements were recorded. During this task reaction times (time until button press for choice) were also measured.

Choice task design

A within-participants design with 2 manipulations (first fixation/control) \times 2 product categories (food/nonfood) \times 2 decision types (most wanted/least wanted) was employed. In total, participants made 144 choices (i.e., 144 trials). The structure of the choice task was as follows: In each trial, participants chose between two

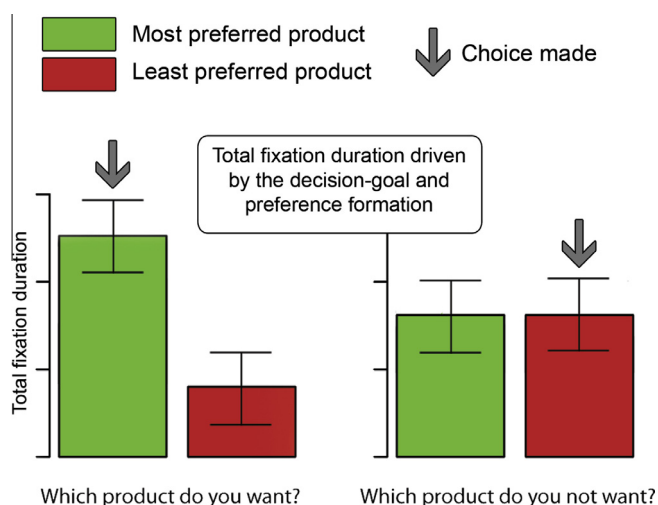


Fig. 1. Hypothesized pattern of total fixation duration under the assumption that both decision goal and preference formation influence total fixation duration in a binary choice. When the question is, “Which product do you want to have”, both effects are in the same direction, resulting in a large difference in total fixation duration between the most and least preferred product. When the question is “Which product do you not want to have”, the effects counteract each other, resulting in a small/absent difference in total fixation duration between the most and least preferred product.

products, displayed left and right on the computer screen, by pressing the left or right arrow key on the keyboard (Fig. 2). A trial lasted as long as it took the subject to make a choice ($M = 3035$ ms, $SD = 2229$ ms).

Participants chose either between two snack products (food condition: 72 trials per subject) or two dish washing agents (non-food condition: 72 trials). Trials were presented in two separate blocks of 72 trials of the least wanted and the most wanted decision type. In the most wanted decision-type participants had to indicate which of the products they wanted to have. In the least wanted decision type participants had to indicate which of the products they did not want to have. The order of the blocks was counterbalanced across participants, i.e., half of the participants started with the most wanted and half started with the least wanted decision type.

To assess the influence of the first fixation, the initial fixation direction at the onset of the trial was manipulated (Fig. 2). To manipulate the fixation direction the calibration sign (a fixation cross) was presented either in the middle of the screen (control condition, 72 trials), or at the location of one of the two items (i.e., left or right, first fixation manipulation condition, 72 trials) 500–1000 ms before each choice-trial began. In half (36) of the 72 manipulation trials, the manipulation was on the right side. In the other half the manipulation was on the left side. The order of left/right manipulations and control trials was randomized separately for the two choice blocks to make sure that equal amounts of manipulation and control trials were presented in the most and least wanted condition. To ensure the effectiveness of the manipulation, participants were instructed that the calibration sign was presented before each trial to fine tune the calibration of the eye tracker and that they were required to look at it. Participants were not aware that the purpose of the calibration sign was to manipulate their first fixation. We used a random exposure to the calibration sign between 500 and 1000 ms to make the onset of the actual choice unpredictable. With a fixed exposure time, anticipation effects can become quite substantial in participants just before a stimulus appears, as they catch on to the timing of the experiment. Variable exposure time for the calibration sign can mitigate this anticipation effect.

The first fixation manipulation was considered successful if the first fixation was on the object on the same side of the screen as the manipulation sign (e.g., first fixation on the right product if the manipulation sign was on the right). The first fixation manipulation was successful in 86.8% of the manipulation-trials.

Only successful manipulation trials were included in the analyses of the effect of the first fixation manipulation.

Choice pairs were matched on preference because it was expected that choice would be primarily driven by pre-existing preference and the effect of the first fixation manipulation would be relatively small. Moreover, matching the choice sets on pre-existing preference enables us to study fixation allocation accompanying preference formation. As there was no initial preference for any of the two options, preference had to be formed during the task. With preference formation we refer to the process of establishing a preference for one of the items of the choice set. The pairs were matched by ranking the participant's preference ratings (as indicated earlier in the session) of all stimuli of the respective category (food/nonfood) and then combining two consecutive stimuli. This was done for each participant. Thus, every participant had a different set of choices, matched on basis of her own preference-ratings and each stimulus was only used one time in the choice task. This approach resulted in 95.3% of the pairs being exactly matched and 4.6% of the pairs having one point difference. In 0.1% of the pairs the difference in rating between the two options was two points or larger. Only choices between two products with no difference in pre-existing (self-reported) preference were included in the analyses.

Stimuli

Stimuli were 144 images of packaged food products and 144 images of packaged nonfood products that were introduced in the U.S., Canada, U.K., and Australia between 2005 and 2010. Food stimuli included pictures of snack foods, such as cookies, crisps, and muesli bars. The nonfood category consisted of pictures of bottled dish washing liquids. This type of nonfood was chosen as a low involvement product. Food is a primary reward that inherently attracts more attention than nonfood stimuli within the daily consumer goods category. Evidence for the lower involvement for nonfood stimuli comes from eye-tracking and neurobiological studies that revealed that nonfood stimuli attract less attention than food stimuli, as witnessed by lower fixation durations (Castellanos et al., 2009; Nijs, Muris, Euser, & Franken, 2010) and lower activation in the visual cortex (Smeets, Kroese, Evers, & De Ridder, 2013; Van der Laan, De Ridder, Viergever, & Smeets, 2011). It was expected that, if existent, the effect of the first fixation manipulation would be more pronounced in a low involvement product because people are rather indifferent in which one they will obtain. Non-Dutch

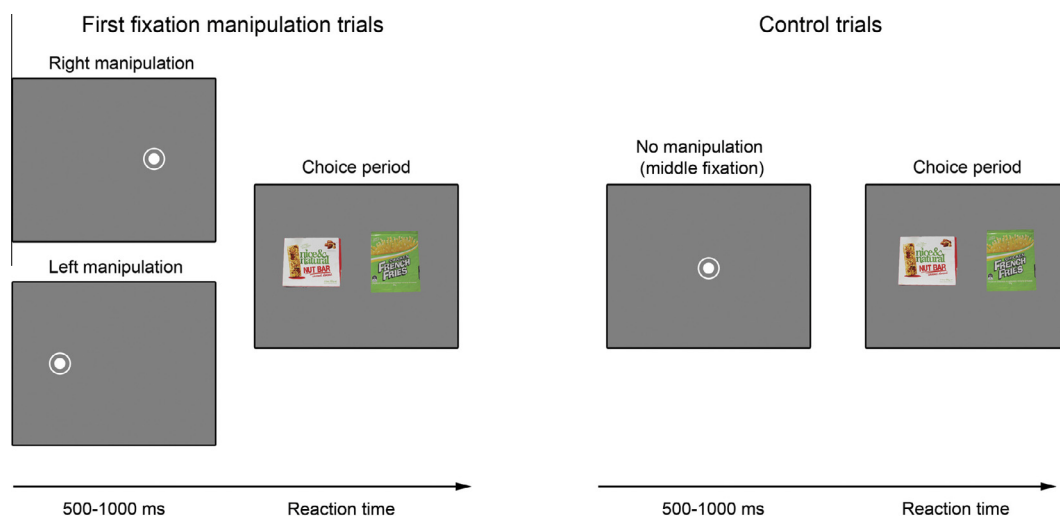


Fig. 2. Choice task trial structure.

products were used to avoid that people would recognize and choose products that they normally use. Each stimulus was only used once in the choice task. All pictures were presented on a neutral gray background (RGB: 128, 128, 128), similar to the background of the calibration screen, to avoid large changes in luminance between the trials. We did this for several reasons. First, an excessive light background may cause small pupils which decrease the variable error of the eye-tracker (Holmqvist & Nyström, 2011; Nyström, Andersson, Holmqvist, & Van de Weijer, 2013 (p. 448)). Second, changes in luminance may also decrease eye-tracking data quality because it may cause systematic position errors in the eye-tracking data (Drewes, Masson, & Montagnini, 2012).

Apparatus

Eye movements were recorded at 52 Hz with an Easygaze TM eye tracker by Design Interactive. The recording was binocular. Following calibration, eye position errors were less than 0.5°. The choice task was presented with Matlab (MathWorks Benelux, n.d) on a monitor with screen resolution 2080 × 1024 pixels. Participants were seated at 58 cm distance away from the monitor and placed their chin on a chin rest during the recording.

Fixation detection was established by marking fixations with an adaptive velocity threshold method, with 58 ms as (default) lower cut-off for a single fixation duration (same as in Toffolo, Van den Hout, Hooge, Engelhard, & Cath, 2013). Fixation detection was done by a self-written Matlab program that marked fixations by an adaptive velocity threshold method. Adaptive velocity threshold methods are well acknowledged and commonly used to define fixations (Engbert & Kliegl, 2003; Nyström & Holmqvist, 2010; Smeets & Hooge, 2003). Here we used an adaptive velocity method that was developed to work with data from low frequency eye trackers (Hooge & Camps, 2013), which are commonly used in eye-tracking studies on consumer choice (e.g., Krajbich et al., 2010). Compared to data from higher speed eye trackers, there are less saccade samples in data from low frequency eye trackers (± 50 Hz), therefore it is better to detect fixations than saccades in low frequency data (Hooge, 2011). Velocities were obtained by fitting a parabola through three subsequent data points. We used the derivative of this fitted parabola to estimate the value of the velocity of the second (center) data point. This procedure was repeated for all data points (except the first and the last). In the present analysis, everything that is not a saccade is called a fixation. To remove the saccades from the signal we calculated the average and standard deviation from the absolute velocity signal. All data points having absolute velocities higher than the average velocity plus 3 times the standard deviation were removed. This procedure was repeated until the velocity threshold converged to a constant value or the number of repetitions reached 50. The velocity of saccade samples originate from a distribution other than velocity from fixation samples. Comparison of velocity is an effective method to distinguish between fixation and saccade samples. Comparison with hand-detected fixations revealed that fixation detection by removing samples with high velocities with the 'iterative 3SD' rule give the best results for 50 Hz data (Hooge, 2011).

Eye-tracking measures

To analyze eye-movements, for each trial the screen was divided into four areas of interest (AOI), namely, 'right product', 'left product', 'middle', and 'not'. These AIO are defined as follows: 'right product', the outline of the right product; 'left product', the outline of the left product; 'middle', a circular area 2.5° around the center of the fixation point; and 'not', everywhere else on the screen. We

calculated total fixation duration, which is the sum of all fixations on an AOI over the course of a trial (Reisenberg, 2013).

A fixation was defined as the first fixation on a product if it was indeed the first fixation on a product during that trial, but also if it was preceded by a fixation in the 'middle' or 'not' regions. To illustrate, if the first fixation during a trial was on the left product, the left product is the first fixated product in that trial. If the first fixation during a trial is on the 'middle' area, followed by a fixation on the left product, the left product is first fixated in that trial. This is a commonly used approach to determine on which product the eyes land first during a trial.

Data-analysis

Reaction times during choices were log-transformed. For ease of interpretation, however, means and standard errors were transformed back and reported in (milli)seconds. Trials with extreme reaction times (>3 SD from the mean) were set to missing. Since stimuli were nested within trials, and trials were nested within participants, multi-level regression analyses (also known as hierarchical linear regression analysis or random effects analysis) were performed to investigate how the manipulation affected choice, and how log reaction time, the location of the first fixation, and total fixation duration were associated with choice. Multi-level analyses are recommended when there are repeated measurements within individuals (Snijders & Bosker, 2012) and trials as is the case in the within-subjects design of the present study. Multi-level analysis takes into account that each level is a (potential) source of unexplained variability (Snijders & Bosker, 2012). In each of the analyses, random intercepts are added for the lower levels (i.e., random intercepts for participants in the two-level models and random intercepts for participants and trials in the three-level models). The purpose of adding a random intercept for participant is to take into account that the measurements from within one participant might not be independent (e.g., there might be differences between individuals in log reaction times). The random intercept of participant denotes the variation in the dependent variable caused by differences between participants. Moreover, the purpose of adding a random intercept for trial is to take into account that measurements from one trial are not independent. The random intercept of trial denotes the variation in the dependent variable caused by differences between trials. In the present study, we are not interested in the variation caused by the levels themselves; however, for completeness we do report the variation of the random effects in the tables of the results. This is in line with recommendations for reporting multi-level analyses (Snijders & Bosker, 2012). Details on the variables included in the four multi-level regression analyses can be found in the following paragraphs. The statistical program R (packages lme4 and languageR) was used to perform multi-level regression analyses (R Development Core Team, 2007).

First fixation manipulation

To test the effect of the first fixation manipulation, we performed a multi-level logistic regression analysis in the successful manipulation trials, with whether the stimulus was chosen (1 if the stimulus was chosen, 0 if not chosen) as dependent variable and manipulation (1 if manipulation was to the stimulus, 0 if manipulation was not to the stimulus), an interaction term of manipulation × decision-type and an interaction term of manipulation × category as fixed explanatory variables. Because the dependent variable (whether the stimulus was chosen) was on stimulus level, and choices were between two stimuli, there were two rows in the dataset per trial. Furthermore, because stimuli were nested in trials and trials were nested in participants, trial and participant were included as random variables in the analysis.

In order to test for effects of the first fixation manipulation, this analysis was performed in the successful manipulation trials (i.e., trials in which the first fixation was on the right product if the manipulation sign was on the right or in which first fixation was on the left product when the manipulation sign was on the left).

Reaction times during choice

To test whether log reaction times differed between decision-types and product categories, we performed a multi-level linear regression analysis in all trials, with as dependent variable log reaction time and as fixed explanatory variables decision-type (most wanted or least wanted) and product category (food or non-food). Reaction time was measured per trial. As trials were nested in participants, participant was included as random variable in the analysis. This analysis was performed in all trials because we did not expect that the manipulation would affect reaction times.

First fixation in control trials

Besides the effect of manipulating the location of the first fixation, we also aimed to investigate how the location of the first fixation related to choice when this was not manipulated (i.e., in control trials). To test whether the item that was fixated on first in the trial was more likely to be chosen, we performed a multi-level logistic regression analysis in control trials with whether the stimulus was chosen (1 if it was chosen, 0 if it was not chosen) as dependent variable and whether the item was first fixated (1 if it was the item first fixated, 0 if it was not), an interaction term of first fixation \times decision-type and an interaction term of first fixation \times category as fixed explanatory variables. As the dependent variable (whether the stimulus was chosen) was on stimulus level, and choices were between two stimuli, there were two rows in the dataset per trial. Similarly, because stimuli were nested in trials and trials were nested in participants, trial and participant were included as random variables in the analysis.

Total fixation duration in control trials

To test whether chosen items were fixated on longer and whether this effect differed between decision-types, we performed a multi-level linear regression analysis in control trials with total fixation duration for a stimulus as dependent variable and whether the stimulus was chosen (1 if the stimulus was chosen, 0 if it was not), decision-type (most wanted or least wanted) and an interaction term of whether the stimulus was chosen \times decision-type as fixed explanatory variables. As the dependent variable (whether the stimulus was chosen) and the explanatory variable total fixation duration were measured on stimulus level, and choices were between two stimuli, there were two rows in the dataset per trial. Similarly, because stimuli were nested in trials and trials were nested in participants, trial and participant were included as random variables in the analysis. As the first fixation manipulation

influenced eye-movements (location of first fixation), we performed this analysis in control trials.

Results

First fixation manipulation

The target product (the product towards which the first fixation was manipulated) was chosen in 50.8% of the manipulation trials. Logistic regression analysis (Table 1) showed that there was no significant effect of manipulating the first fixation to a product on the likelihood of it being chosen ($p = 0.15$). The results showed no significant interaction with decision type ($p = 0.94$), which indicates that the (non-significant) effect of the manipulation did not differ between the most and least wanted decision type. A marginally significant interaction-term of manipulation with product category ($p = 0.06$) was found: In 48.2% of the food trials the target was chosen, compared to 53.4% of the non-food trials.

Reaction times during choice

The regression analysis (Table 2) showed that reaction times (time until button press for choice) were significantly longer for the food ($M = 2659$ ms, $SE = 1023$ ms), compared to the nonfood category ($M = 2240$ ms, $SE = 1023$ ms, $p < 0.01$). Also, reaction times were significantly longer for the least ($M = 2616$, $SE = 1023$ ms) compared to the most wanted decision type ($M = 2279$ ms, $SE = 1023$ ms, $p < 0.01$).

First fixation in control trials

In the control trials, the item first fixated on was chosen in 50.4% of the trials. The logistic regression analysis (Table 3) showed that stimuli that were fixated on first were not more likely to be chosen ($p = 0.88$). The results showed no significant interaction of

Table 1

Multi-level logistic regression results: effects of first fixation manipulation and interaction with decision type and product category.

Model effect	Estimate	Std. error	Z-value	p
<i>Fixed effects</i>				
Intercept	−0.03	0.06	−0.56	0.58
First fixation (manipulation)	0.16	0.11	1.44	0.15
First fixation (manipulation) \times decision type	0.01	0.11	0.07	0.94
First fixation (manipulation) \times category	−0.21	0.11	−1.85	0.06
Model effect		Variance		SD
<i>Random effects</i>				
Intercept (level 2 trial)		2.0863×10^{-15}		4.5676×10^{-8}
Intercept (level 3 subject)		0		0
Log-likelihood model		−1764		
AIC		3540		

Table 2

Multi-level logistic regression results: association between (log) reaction times and decision type and product category.

Model effect	Estimate	Std. error	T-value	p
<i>Fixed effects</i>				
Intercept	1.04	0.10	10.85	<0.01
Decision type	−0.12	0.02	−7.48	<0.01
Product category	−0.17	0.02	−10.03	<0.01
Model effect		Variance		SD
<i>Random effects</i>				
Intercept (level 2 subject)		0.19808		0.44506
Log-likelihood model		−1922		
AIC		3854		

Table 3

Multi-level logistic regression results: association between first fixation and choice in control trials and interaction with decision type and product category.

Model effect	Estimate	Std. error	Z-value	p
<i>Fixed effects</i>				
Intercept	−0.02	0.05	−0.31	0.76
First fixation	−0.02	0.10	−0.16	0.88
First fixation × decision type	−0.01	0.10	−0.10	0.92
First fixation × category	0.11	0.10	1.03	0.30
Model effect		Variance		SD
<i>Random effects</i>				
Intercept (level 2 trial)		0		0
Intercept (level 3 subject)		0		0
Log-likelihood model		−2076		

Table 4

Multi-level logistic regression results: association between total fixation duration and choice and interaction with decision type.

Model effect	Estimate	Std. error	t-Value	p
<i>Fixed effects</i>				
Intercept	940.453	112.33	8.37	<0.01
Choice	59.06	27.10	2.18	0.03
Decision type	−206.00	37.47	−5.5	<0.01
Choice × decision type	122.97	38.25	3.22	<0.01
Model effect		Variance		SD
<i>Random effects</i>				
Intercept (level 2 trial)		251,662		501.66
Intercept (level 3 subject)		262,329		512.18
Log-likelihood model		−23,810		

first fixation with decision type ($p = 0.92$) and product category ($p = 0.30$), which indicates that the (non-significant) effect of the first fixation did not differ between the decision types and the product categories.

Total fixation duration in control trials

The regression analysis (Table 4) showed a significant gaze bias for chosen alternatives in both conditions ($p = 0.03$): participants had a longer total fixation duration on the chosen items ($M = 964$ ms; $SE = 24$ ms) than on the not chosen items ($M = 844$ ms; $SE = 22$ ms). Important to note is that the chosen item in the most wanted decision type is the eventually preferred item, while in the least wanted condition the chosen item is the eventually less preferred one. There was a significant interaction between choice and decision type ($p < 0.01$, Fig. 3): the difference in total fixation duration on chosen versus not chosen items was larger in the most wanted decision type (chosen minus not chosen $M = 183$ ms, $SE = 26$ ms) compared to the least wanted decision type (chosen minus not chosen $M = 59$ ms, $SE = 28$ ms; Fig. 4). Thus, although in both conditions participants fixated longer in total on the product they chose, the gaze bias was larger in the most wanted decision type.

Discussion

The role of the first fixation

Our first aim was to investigate whether the location of the first fixation has a down-stream effect on consumer choice. Our results revealed that irrespective of the instruction manipulating the first fixation did not influence consumer choice, neither for food nor for nonfood products. In addition, in the control trials where the first fixation was not manipulated to any of the two alternatives (i.e., first fixation was allocated naturally), there was no association between first fixation and choice. Thus, it appeared that the

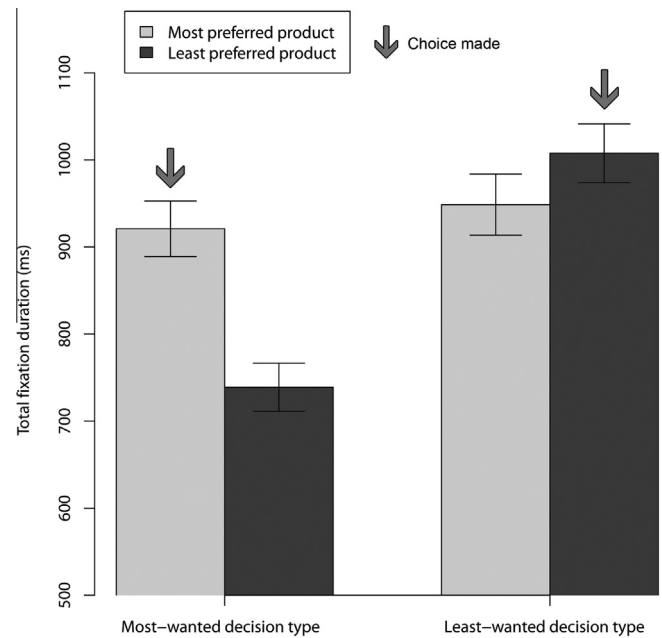


Fig. 3. Total fixation duration (mean ± SE) of chosen and not chosen stimuli by decision type.

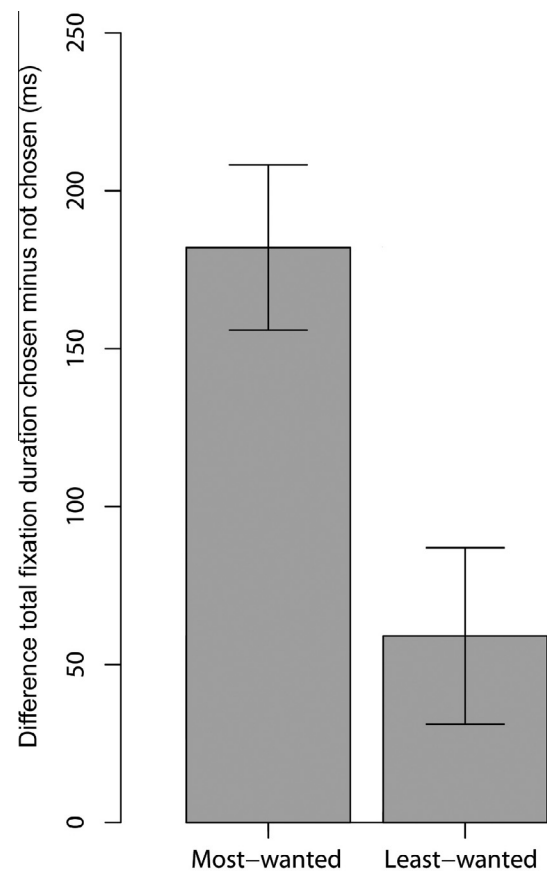


Fig. 4. Difference in total fixation duration (mean ± SE) for chosen minus not chosen stimuli by decision type.

location of the first fixation did not have a down-stream effect on consumer choice.

To our knowledge, this is the first study that experimentally manipulated the location of the first fixation to investigate its

effect on consumer choice. Whereas other studies showed that factors influencing the location of the first fixation also influenced consumer choice (e.g., the place on the shelf, manipulating the packages' visual attributes (e.g., Chandon et al., 2009; Milosavljevic et al., 2012), it was unknown whether the first fixation played a role in that effect. Our experimental manipulation enabled us to investigate the influence of manipulating the location of the first fixation, without altering visual attributes of the stimulus itself. Our experimental design was optimized to detect even the smallest effect of the manipulation. First, because we expected that choice is mainly based on pre-existing preference, we matched choice pairs on self-reported preference. Second, we did not only include 'high-involvement' consumer products, but also low-involvement products (dish-washing liquids). For the latter we assumed that participants were indifferent about which one to obtain, and thus choice would be more easily biased. The indifference for dish-washing liquids was confirmed by the shorter response time for the dish-washing trials compared to the food trials. Thus, our results suggest that the location of the first fixation has no down-stream effect on consumer choice.

Earlier studies on the association between first fixation location and choice showed mixed results (e.g., Atalay et al., 2012; Glaholt & Reingold, 2009b; Krajbich et al., 2010; Schotter et al., 2010). However, these studies did not experimentally manipulate the first fixation and most studies did not match the alternatives on pre-existing preference. Therefore, the choice-bias for firstly viewed alternatives in these studies might be explained by (1) top-down effects of pre-existing preferences or (2) downstream effects of fixation duration on choice, i.e., visually salient alternatives are fixated on longer (Lohse et al., 1997; Bialkova & van Trijp, 2011; Navalpakkam et al., 2012; Orquin et al., 2013) and thereby affect the decision in favor of the attended product (Armel et al., 2008; Shimojo et al., 2003).

Our findings for the first fixation appear to contradict with gaze cascade and evidence accumulation models, which predict that alternatives fixated on first are more likely to be chosen. These models suggest that the location of the first fixation plays an important role in the decision-process. Studies concerning the gaze 'cascade effect' (Armel et al., 2008; Shimojo et al., 2003), have suggested that gaze allocation both reflects and influences preference through preferential looking and mere exposure, respectively. Therefore, this theory predicts that the alternative that is looked at first has an initial advantage through the mere exposure effect (Simion & Shimojo, 2006). Evidence accumulation models (e.g., the drift diffusion model, Krajbich et al., 2010) assume that evidence in favor of an alternative is accumulated during fixations. The decision is made when the accumulated evidence passes a certain threshold towards one of the alternatives. Therefore, these theoretical models would also predict that manipulating the first fixation towards an alternative would increase the likelihood of it being chosen. Our empirical findings, and earlier studies that failed to find a relation between the location of the first fixation and choice (Glaholt & Reingold, 2009b; Atalay et al., 2012) therefore question the role of the first fixation location in evidence accumulation and preference formation. Consequently, the role of the location of the first fixation in the evidence accumulation model should be reconsidered. Our finding – no effect of first fixation on choice – is congruent with the gate-keeping hypothesis proposed by Orquin and Mueller-Loose (2013). They suggested that the first fixation itself does not influence preference for an item but that fixations driven by visual salience might influence choice by gate-keeping the alternatives that enter the consideration set (the set of alternatives that are considered for choice). Accordingly, visually salient items are more likely to attract (first) fixations and to enter the consideration set, while less visually salient items that fail to capture attention and do not enter the consideration set are therefore

less likely to be chosen. Future studies should further test the gate-keeping hypothesis by employing choice paradigms with larger choice sets.

Naturally, a product has to be noticed on the shelf, to have a chance of making it into the basket. However, an important implication of these findings for in-store marketing is that it is not necessary to catch the first gaze of the consumer. Considering that other studies showed that preference can be manipulated by increasing the fixation duration (Armel et al., 2008; Shimojo et al., 2003), it might be more effective to design packages that retain attention.

Disentangling the effects of the decision goal and preference formation on the gaze bias

Looking longer at chosen items (often referred to as 'gaze bias' (Schotter et al., 2010)) in consumer choice situations is often attributed to down-stream effects of fixation duration (i.e., gaze allocation that accompanies preference formation (the process of establishing a preference for one of the items of the choice set), e.g., Shimojo et al., 2003; Krajbich et al., 2010), while it might also be caused by processes of top-down attention such as the decision-goal (Orquin & Mueller-Loose, 2013). Therefore, we aimed to disentangle the effects of two factors on total fixation duration, namely the decision goal and preference formation. We found that both in the most wanted and the least wanted decision type the total fixation duration was longest for the product of choice. This suggests that the decision goal was the main driver of the gaze bias. It is important to note that the chosen alternative is the eventually most preferred one in the most wanted decision type but the eventually least preferred one in the least wanted decision type. However, the finding that the patterns of total fixation duration on chosen and not chosen item in the two conditions were not simply mirrored (which would suggest that only the decision goal influences fixation duration), indicates that total fixation duration was also influenced by preference formation. The difference in total fixation duration between chosen and not chosen items was larger in the most wanted compared to the least wanted decision type. Thus, although total fixation duration was highest on the chosen product in both conditions, the gaze bias was larger in the most wanted decision type. This is in line with our hypothesis that both the decision goal and preference formation affect total fixation duration: in the most wanted decision type, these effects are in the same direction, augmenting the gaze bias, while in the least wanted decision type these effects counteract each other.

Our findings are partly in line with the findings of Schotter et al. (2010), who investigated fixation time in a choice task in which participants had to indicate the most/least beautiful face. However, in their study, effects of preference formation and effects of pre-existing preference could not be separated because their choice pairs were not matched on pre-existing preference. Matching the products on pre-existing preference is crucial to rule out that the gaze bias for the preferred product is the result from top down effects of pre-existing preference, rather than preference formation. In the study of Schotter et al. (2010) preference (either pre-existing preference or down-stream effects of fixation allocation during preference formation) completely canceled out the gaze bias in the dislike decision type.

Results from this study have important implications for the interpretation and design of commercial eye tracking studies as they suggest that the gaze bias in these studies is mainly driven by the decision goal (i.e., the task requirements), and to a smaller extent by preference formation. This emphasizes the importance of the instruction in these studies.

Several features of our experimental design, which are not common in the consumer research literature, are worth emphasizing.

We collected data on a very large number of trials within participants, but only for a relatively small number of participants, which is standard practice in eye-tracking research and neuroscience. The ratio between number of participants and number of trials per participant allows characterizing the value of the outcome measurements for each individual participant with great precision. Furthermore, a small number of participants is sufficient because there is often limited variation in the estimated properties of the underlying visual systems across participants (Milosavljevic et al., 2012). Accordingly, many earlier studies on the relation between visual characteristics and consumer choice or preference decisions included similar or even much lower numbers of participants and similar numbers of trials per participant (Bialkova & van Trijp, 2011, 2010; Gatti, Bordegoni, & Spence, 2014; Milosavljevic et al., 2012, Simion & Shimojo, 2006; Krajbich et al., 2010).

For generalizing to 'consumers' at large our study has a relatively low sample size. Considering that consumer responses in general are heterogeneous, it is desirable to include higher numbers of participants. However, earlier studies with similar or even lower numbers of participants yielded valid and reliable results, as witnessed by a high sensitivity to detect top down and bottom up processes in attention to front-of-pack nutrition labels, in different types of consumers (Bialkova & van Trijp, 2011). Moreover, in our study we did not even see a trend towards a significant influence of first fixation on consumer choice. Therefore, we consider it unlikely that that we would have found significant effects for the first fixation manipulation with a higher number of participants. Moreover, if this effect would only show up after inclusion of a higher number of participants, the effect would be so small that it might not be relevant for consumer choice in practice. Thus, we are confident that our results hold for our study population. Notwithstanding this, confirmation with larger samples may add to the robustness of our findings.

The study used a binary choice task, which is a commonly used and generally accepted approach to investigate consumer choice (e.g., Bialkova & Van Trijp, 2011; Hare, Camerer, & Rangel, 2009; Hare, Malmaud, & Rangel, 2011; Krajbich et al., 2010). Studies showed that when participants are giving a choice set of more many options (e.g., in the supermarket) they tend to take only a subset of alternatives under consideration, referred to as the 'consideration set'. Alternatives outside this consideration set are ignored. It has been demonstrated that within multi-alternative choice sets, people use mostly pair-wise comparisons (Russo & Leclerc, 1994; Russo & Rosen, 1975). Alike other studies that used binary choices, we investigated choices from within the consideration set. It remains an important topic to investigate how consideration sets develop, which alternatives enter the set, and which are ignored.

Conclusion

Our findings suggest that the location of the first fixation has no down-stream effect on consumer choice. Therefore, catching the first gaze of the consumer might be unnecessary. We found that total fixation duration was mainly determined by the effect of decision goal and to a smaller extent by fixation allocation accompanying preference formation. This finding emphasizes the importance of task instruction in marketing oriented eye tracking research and suggests that total fixation duration cannot be interpreted as a direct proxy for preference.

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