Food Quality and Preference 47 (2016) 130–138

Contents lists available at ScienceDirect

Food Quality and Preference

journal homepage: www.elsevier.com/locate/foodqual

Design factors influence consumers' gazing behaviour and decision time in an eye-tracking test: A study on food images

Thi Minh Hang Vu [a,b,*], Viet Phu Tu [b], Klaus Duerrschmid [a]

[a] Department of Food Science and Technology, University of Natural Resources and Life Sciences Vienna, Muthgasse 18, 1190 Vienna, Austria
[b] School of Biotechnology and Food Technology, Hanoi University of Science and Technology, 1 Dai Co Viet Road, Hanoi, Vietnam

ARTICLE INFO

Article history:
Received 30 November 2014
Received in revised form 28 May 2015
Accepted 28 May 2015
Available online 29 May 2015

Keywords:
Eye-tracking
Gazing behaviour
Decision time
Design factor
Food image

ABSTRACT

The eye-tracking method has been increasingly used for studying consumer behaviour over the last few years. Understanding factors influencing consumers' gazing behaviour in an eye-tracking test will contribute to a better organisation and a more valid application of the method. The aim of this work is to study how test design influences gazing behaviour and decision time of food consumers in an eye-tracking test. Three factors of the test design were investigated: (1) *Number of images* in one testing picture (two, three, four, five, and six images/picture); (2) *content of question* (tastiness, healthiness, price, convenience, and familiarity); and (3) *type of evaluation* (maximum choice, minimum choice, ranking, rating, and grouping). Two experiments were conducted. In the first experiment, performed with 100 participants, the influence of individual factors was studied. In the second experiment, performed with 64 participants, the joint effects (interactions) of the tested factors were investigated. The results showed that gazing behaviour and decision time are strongly influenced by the *type of evaluation* and the *number of images*, but not by the *content of question*. No joint effect of influencing factors (*number of images* and *type of evaluation*) was found. Findings are discussed in considering the relationship between eye-movements, cognitive goals, and tasks. This study highlights the importance of understanding factors influencing gazing behaviour and decision time in an eye-tracking test.

1. Introduction

1.1. Eye tracking applications in sensory and consumer science

The eye-tracking technique permits observation and measurement of the movement of eyes when consumers receive a visual stimulus or view a product. The information regarding their gazing behaviour is collected in an objective, rapid, and non-invasive way (Graham, Orquin, & Visschers, 2012). An attached device or sensor will record the eyes' movements, mark the observed region, and mark the time that the eyes stopped in each region, reflecting the observer's attention and interest levels for each zone of the visual stimulus (Russo, 1978). A number of different measures such as *time to first fixation*, *fixations before*, *fixation duration*, and *fixation count*, can be used to characterise the gazing behaviour. By analysing those measures, the gazing behaviour of consumers and influencing factors can be described, and then relationships to other important behavioural aspects such as choice behaviour can be determined. Therefore, the eye-tracking technique has great potential for objective observational studies in sensory and consumer science.

In the food sector, eye-tracking technique has mainly been applied in packaging research. By recording the dwell times and the areas that consumers pay attention to, an eye-tracker can determine how packaging attracts consumer attention. Some studies conducted a free-viewing task but varied stimulus-driven attention to study how packaging attributes (layout, nutrition label, etc.) affect consumer gazing behaviour and then suggest how to develop an appropriate packaging design (Piqueras-Fiszman, Velasco, Salgado-Montejo, & Spence, 2013; Rebollar, Lidón, Martín, & Puebla, 2015; Siegrist, Leins-Hess, & Keller, 2015). Others conducted a specific task, such as evaluating the healthiness of a product and the willingness to purchase or to try the product, to study the goal-oriented attention (Ares et al., 2013; Bialkova & van Trijp, 2011; Graham & Jeffery, 2012; van Herpen & Trijp, 2011). The eye-tracking technique is also applied to access visual stimuli of food products in order to evaluate the consumer perception of sensory properties such as colour,

* Corresponding author at: Department of Food Science and Technology, University of Natural Resources and Life Sciences Vienna, Muthgasse 18, 1190 Vienna, Austria.

E-mail addresses: hang.vu-thi-minh@students.boku.ac.at, hang.vuthiminh@hust.edu.vn (T.M.H. Vu).

http://dx.doi.org/10.1016/j.foodqual.2015.05.008
0950-3293/

expected tastiness intensities (Jantathai, Danner, Joechl, & Dürrschmid, 2013) or consumer perception of quality factors such as healthiness (Mitterer-Daltoé, Queiroz, Fiszman, & Varela, 2014). Moreover, eye-tracking strongly contributed to the study of factors which might influence choice and consumer behaviour such as eating motivation (ex: negative mood, attentional avoidance) (Hepworth, Mogg, Brignell, & Bradley, 2010; Werthmann, Roefs, Nederkoorn, & Jansen, 2013), decision goal, and thinking style (Ares, Mawad, Giménez, & Maiche, 2014; Milosavljevic, Navalpakkam, Koch, & Rangel, 2012). Furthermore, several studies used eye-tracking to understand how psychological illnesses and food-related health status, such as anorexia nervosa, eating disorder, or BMI status, influence consumers' choice and food habits (Giel et al., 2011; Graham, Hoover, Ceballos, & Komogortsev, 2011; Horndasch et al., 2012). Hence, eye tracking is proving to be a useful tool for studying consumer perception and behaviour by gaining information in an objective way.

1.2. Design in an eye-tracking test

To achieve more valid data from eye-tracking, the question of how to design a test becomes exigent. However, only a few publications focused on this issue (Duchowski, 2007). As a result, large variations in test design were observed in the above-mentioned studies. The variations in the eye-tracking tests include: *number of images* per picture (varying from 1 to 10); *content of question* (preference, perception of healthiness, willing to try, willing to purchase, or expected intensities of sensory properties of food products); and *type of evaluation* (free viewing-task, forced choice, rating, ranking, or projective mapping).

Depending on the research purpose, each author designed his or her tasks differently. It might be that some authors did not consider the influence of the chosen design factors. In our opinion, the outcomes of above studies sometimes could not only be the result of the mechanisms under the study but also be biased by the chosen design parameters. Are there any influences of test design on consumer gazing behaviour? If yes, which design factors are influencing the gazing behaviour, and how? Finally, how should tasks in an eye-tracking test be designed?

1.3. Relationship between eye movement mechanisms, cognitive goals and task

It has been demonstrated that eye movement is coextensive with cognition, and oculomotoric processing is coextensive with cognitive processing (chap. 30, Liversedge, Gilchrist, and Everling (2011)). Eye movements are reported as highly task dependent and linked to cognitive goals (Castelhano, Mack, & Henderson, 2009).

Firstly, eye movements depend on the question including the content and the type of evaluation. Yarbus (1967) found that the task might influence patterns of eye movements. In his experiments, the same picture was presented to participants but with different questions. Consequently, different eye movement patterns were obtained. Recent studies also found similar results (Glaholt, Wu, & Reingold, 2010; Glöckner, Fiedler, Hochman, Ayal, & Hilbig, 2012; Kim, Seligman, & Kable, 2012).

Secondly, eye movements depend on the difficulty of the task. Hess and Polt (1964) were the first to observe that a person's pupils dilate when a difficult task is resolved. As the multiplication problems in their test became more difficult, pupil dilations increased steadily. More recently, Knoblich, Ohlsson, and Raney (2001) and Jones (2003) found that, in a difficult task, mean fixation duration increased significantly. They explained that participants need impasse stages (long gazes without making any moves) for cognitive processes searching for solutions; therefore, the more difficult a task is, the longer the fixation time has to be.

In conclusion, there is in general a relationship between task, cognitive processes, and eye movement mechanisms: depending on tasks, cognitive processes will change, and eye movements will follow and reveal the change of cognitive processes. These findings suggest that test design may considerably influence the results of an eye-tracking test, in the fields of both consumer science and psychology.

2. Research questions

Understanding the way to design a test will contribute to a better organisation and a more valid application of the test (Fig. 1). Hence, the objective of our study is to understand which factors of the test design influence consumer gazing behaviour, and how they influence them.

2.1. Tested design factors

In consumer behaviour studies, the task in an eye-tracking test is often to make a choice; therefore, eye movements are controlled both by top-down and bottom-up processes (Orquin & Mueller Loose, 2013). Top-down control of attention is usually defined as goal-driven attention and bottom-up control is commonly defined as stimulus-driven attention (Corbetta & Shulman, 2002). Thus, in our study, we tested three factors of the test design: *number of images* per picture, *content of question*, and *type of evaluation*. The *number of images* per picture was a factor of stimulus-driven attention. The two others were factors of goal-driven attention. The effect of *content of question* was attributable to individual differences, whereas the *type of evaluation* was caused by experimental manipulations.

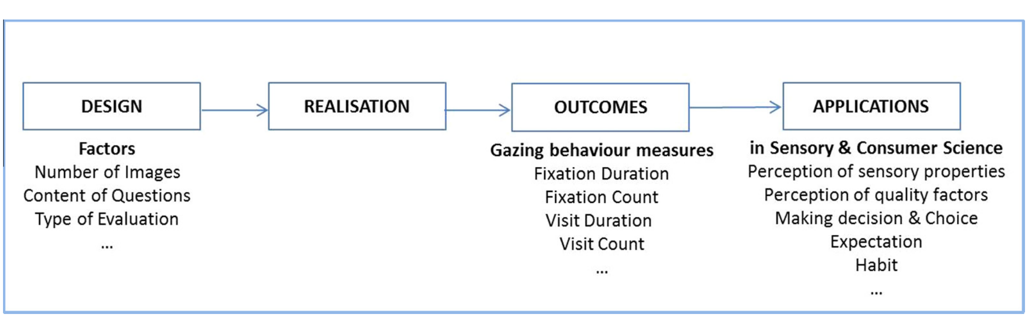

Fig. 1. Eye-tracking test: from design to applications.

(1) *Number of images* in one testing picture (five values: *two*, *three*, *four*, *five*, and *six images*/picture). We limited the total to a maximum of six images per picture in this study.
(2) *Content of question* (five aspects of food: *tastiness*, *healthiness*, *price*, *convenience*, and *familiarity*). These aspects were extracted from the questionnaire of Steptoe, Pollard, and Wardle (1995) on nine factors of food choice. Following their finding, *tastiness*, *healthiness*, *price* and *convenience* were the most important factors that influence people's dietary choices. In addition, *familiarity*, considered as a personality factor that strongly depends on participants' experiences, was also added.
(3) *Type of evaluation* (five types of evaluation: *maximum choice*, *minimum choice*, *ranking*, *rating*, and *grouping*). These types reflect different tasks with different levels of difficulty that are commonly used in consumer studies.

2.2. Gazing behaviour measures

In this study, four measures were used to describe consumer gazing behaviour: (i) *Fixation duration* (duration of individual fixation within AOI, sum of fixation duration was computed [second]); (ii) *fixation counts* (number of times the participant fixates on an AOI [count]); (iii) *visit duration* (durations of individual visit within an AOI, sum of visit duration was computed [second]); and (iv) *visit counts* (number of times that a participant enters an AOI [count]). Fixation duration, which is the time that eyes fixate on an area of interest (AOI), is a sensitive measure of cognitive processing load (Russo & Dosher, 1983). The fixation structure may reflect the way participants perceive information from an image (considered as an AOI). On the other hand, visit, which is the time that eyes visit an AOI, may reflect the way participants compare information between images. A participant can enter an AOI only a few times or in more complex cases many times after looking at other AOIs before having made a decision. Thus, duration and count of fixation and visit are of importance in our case.

2.3. Research questions

According to findings published in the scientific literature, our objective was to answer the following questions:

Q1. Is there any influence of design factors on the consumer gazing behaviour?

Q2. Is there any influence of the design factors on the time for making a decision?

Q3. If Q1 and Q2 are true, is there any joint effect of influencing factors found in Q1 and Q2 on consumer gazing behaviour and decision time?

3. Materials and methods

Two experiments were conducted. The first was performed to study the independent influence of individual factors on consumer gazing behaviour and decision time. The second was performed to study the joint effect of influencing factors on gazing behaviour and decision time.

3.1. Participants

One hundred persons (50 males and 50 females, aged from 18 to 53) participated in the first experiment, and 64 other persons (30 males and 34 females, aged from 12 to 55) participated in the second experiment. All participants had normal and full colour vision. They were recruited from students, staff, and visitors of the University of Natural Resources and Life Sciences in Vienna (BOKU).

The study was performed in agreement with the ethical guidelines for scientific research of BOKU. The participants were informed about the testing procedure and were also asked to give written informed consent before the test.

3.2. Stimuli

Food images purchased from a professional picture provider were used as stimuli (Table 1). The selected images were similar in terms of visual attractiveness, meaning that no image attracted more attention than others to avoid unwanted influence of attractiveness on consumer gazing behaviour. This similarity was shown *ex post* by an analysis of variances (ANOVA), which resulted in no significant effect of food images on gazing parameters.

For the sections "*number of images*" and "*type of evaluation*" in the first experiment, the food images have similar presentations within one group of pictures, e.g., protein rich meals (beef, chicken, mussels, eggs, fish, and shrimp) on a white plate with potatoes (see example in Fig. 2).

For the section "*content of question*", the food images were connected with different consuming situations (fast food, home food, restaurant food, and processed food), aimed to cover all investigated aspects of food products. Although the situations were different, the visual attractiveness was similar (Table 5).

The position of images on the testing picture was fixed to have the same stimulus for all groups of participants.

3.3. Procedure

In the first experiment, participants were separated into five groups (20 persons per group, balanced in terms of sex, coded as Gr1, Gr2, Gr3, Gr4, and Gr5) corresponding with five tested components of each factor. Each group was asked to complete a three-section task corresponding to the three tested factors (Table 2). The section assessing order was the same as sections were independent and separated by a 3-min break.

The second experiment was designed based on the results of the first experiment. Participants in this experiment were separated into four groups (16 persons per group, balanced in terms of sex, coded as GrA, GrB, GrC, and GrD) corresponding with four tested *types of evaluation*: *maximum choice*, *minimum choice*, *ranking* and *rating*. They were asked to observe three testing pictures corresponding to three values of the *number of image* factor: two, four, and six images/picture (Table 3). Within each group, the testing picture order was balanced according to a Williams Latin square.

Table 1
List of food images used in the study.

Section (tested factors)	Number of images (/picture)	Stimulus
Experiment 1		
1. Number of images	2	Soy products–dairy products
	3	Bread–rice–pasta
	4	Vegetable–tuber–cereal–fruit
	5	Whisky–wine–beer–sparkling–cocktail
	6	Beef–chicken–mussel–egg–fish–shrimp
2. Content of question	4	Fast food–home food–restaurant food–processed food
3. Type of evaluation	4	Vegetable–tuber–cereal–fruit
Experiment 2		
Interaction	2	Soy products–dairy products
	4	Vegetable–tuber–cereal–fruit
	6	Beef–chicken–mussel–egg–fish–shrimp

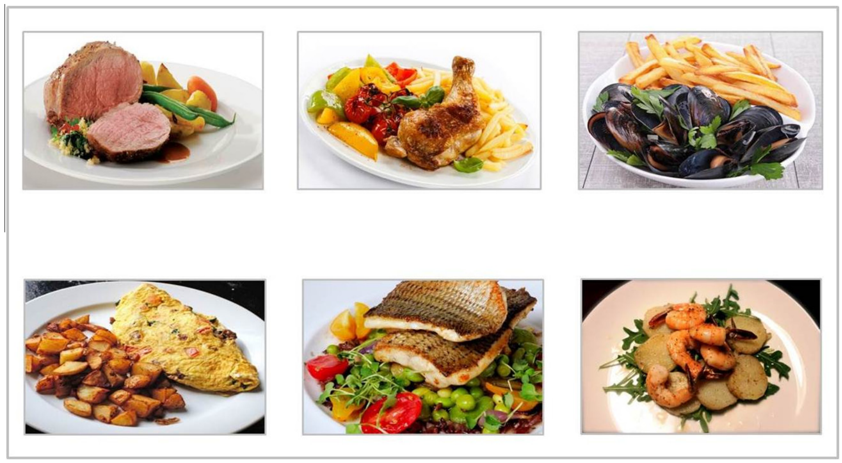

Fig. 2. Example of a testing picture with six food images.

Table 2
Test design of experiment 1.

Section (tested factors)	Group of participants	Number of images (/picture)	Content of question	Type of evaluation	Question
1. Number of images	Gr1	2	Healthiness	Maximum choice	What is the healthiest food?
	Gr2	3			
	Gr3	4			
	Gr4	5			
	Gr5	6			
2. Content of question	Gr1	4	Tastiness	Maximum choice	What is the most delicious food?
	Gr2		Healthiness		What is the healthiest food?
	Gr3		Price		What is the cheapest food?
	Gr4		Convenience		What is the most convenient food?
	Gr5		Familiarity		What is the most familiar food?
3. Type of evaluation	Gr1	4	Healthiness	Maximum choice	What is the healthiest food?
	Gr2			Minimum choice	What is the least healthy food?
	Gr3			Ranking	Ranking the healthiness of products
	Gr4			Rating	Rating the healthiness of products
	Gr5			Grouping	Which products are similar in healthiness?

Table 3
Test design of experiment 2.

Section (tested factors)	Group of participants	Number of images (/picture)	Content of question	Type of evaluation	Question
Interaction	GrA	2	Healthiness	Maximum choice	What is the healthiest food?
		4			
		6			
	GrB	2		Minimum choice	What is the least healthy food?
		4			
		6			
	GrC	2		Ranking	Ranking the healthiness of products
		4			
		6			
	GrD	2		Rating	Rating the healthiness of products
		4			
		6			

For each section, participants received instructions including the highlighted question on the screen. Each section started with a red cross in the middle of the screen for three seconds to fix the participants' gaze at a predefined point before looking at the testing picture. Subsequently, the testing picture appeared on the screen until the participants had the answer in their mind and clicked the mouse. There was no limit to the decision time. Participants were strongly reminded to have the answer in mind before clicking the mouse button to go to the response page. In the response page, gaze was no longer recorded. Depending on the type of evaluation, response page displays were as follows:

- For maximum and minimum choice task, all images were shown. Participants were asked to click on the product that they have chosen.
- For rating task, images were shown one by one with an 11-point scale (from 0 to 10). Participants were asked to click on the points they awarded to each product.

- For ranking task, all images were shown. Participants were asked to click respectively on the-in their opinion-the healthiest, the 2nd, the 3rd, and the least healthy product.
- For grouping task, all images were shown. For each of image, participants were asked to click on the products that they found to be similar in terms of healthiness to the image in question. Then, participants had to repeat the task for three other images.

Pre-tests were conducted to ensure that the procedure was clear and easy to understand for untrained participants.

3.4. Eye-tracking technique

The Tobii T60 eye tracking device and Tobii studio software (version 3.0.5, Tobii Technology AB, Sweden) were used to gain and analyse data on the gazing behaviour of consumers. The pictures were presented on a 17-inch-thin-film transistor LCD monitor with a 1280×1024 pixel resolution. Participants were asked to sit at a distance of approximately 65 cm from the sensor of the Tobii T60 device.

3.5. Data analysis

For the effect of the *number of images* per testing picture, in Section 1 of the first experiment and in the second experiment, AOI was defined as the whole testing picture. Otherwise, in Sections 2 and 3 of the first experiment, AOIs were defined as single food images on the testing picture (Fig. 3).

As mentioned in Part 2.2, for each AOI, four measures of consumers' gazing behaviour were calculated: *fixation duration*, *fixation counts*, *visit duration*, and *visit counts*. Moreover, the time for making a decision, calculated by *time to first mouse click* (the time until the first click is made to go to the next page [second]), was measured to characterise the task difficulty.

In Section 1 of the first experiment, for each of measured parameters, a one-way analysis of variance (ANOVA) was performed using the following model:

$$\textit{Gazing parameter} = \textit{mean} + \textit{main effect for group} + \textit{error}$$

In Sections 2 and 3 of the first experiment, for each of measured parameters, a two-way ANOVA was performed using the following model:

$$\begin{aligned}\textit{Gazing parameter} = \textit{mean} &+ \textit{main effect for AOI} \\ &+ \textit{main effect for group} \\ &+ \textit{interaction AOI} * \textit{group} + \textit{error}\end{aligned}$$

In the second experiment, for each of the measured parameters, a two-way ANOVA was performed using the following model:

$$\begin{aligned}\textit{Gazing parameter} = \textit{mean} &+ \textit{main effect for Section(number of images)} \\ &+ \textit{main effect for group(type of evaluation)} \\ &+ \textit{interaction section} * \textit{group} + \textit{error}\end{aligned}$$

For the decision time, a one-way ANOVA was computed using the following model:

$$\textit{Decision time} = \textit{mean} + \textit{main effect for group} + \textit{error}$$

When the effects were significant, significant differences were calculated using Tukey's test at a significance level of 5%.

Statistical analyses were performed using SPSS 21 and Microsoft Excel 2010.

4. RESULTS

4.1. Experiment 1: the effect of independent factors

4.1.1. Section 1: Number of images/picture

4.1.1.1. Gazing measures. Because AOI was defined as the whole testing picture, no effect of AOIs was observed. *Visit count* values, which were the number of times participants entered into the whole picture, were often one or two; therefore, they were also not taken into consideration.

Results of the ANOVA showed highly significant effects of the *number of images* for *fixation count* and *visit duration* at $p \leqslant 0.01$. The effect on *fixation duration* is not significant on a *p*-level of 0.05, but only on a *p*-level of 0.1. Hence, at least two tested gazing behaviour parameters were influenced by the *number of images* per picture (Table 4 and Fig. 4).

4.1.1.2. Decision time. The one-way ANOVA showed no significant effect of the *number of images* for decision time at $p \leqslant 0.05$. The *p*-value is 0.092; thus, one might speculate about a slight trend towards longer decision times with higher numbers of images (Table 5).

Table 4
ANOVA results: *number of images* – gazing behaviour.

Variation	Gazing behaviour parameters						
	df	Fixation duration		Fixation count		Visit duration	
		F-value	*p*-Value	*F*-value	*p*-Value	*F*-value	*p*-Value
Groups: number of images	4	2.043	0.098	4.240	0.004	4.132	0.004

Fig. 3. Example of AOI defined as the whole picture (left) and as one single image (right).

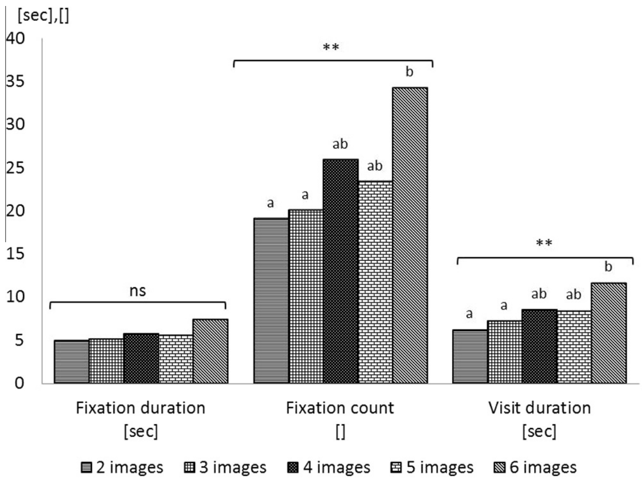

Fig. 4. Gazing behaviour parameters influenced by *Number of images* ^{ns} indicate no significant effect at $p \leqslant 0.05$; ** indicate significant effect at a significance level of $p \leqslant 0.01$.

Table 5
ANOVA results: *number of images – decision time.*

Variation	Time of decision		
	df	*F*-value	*p*-Value
Number of images/picture	4	2.085	0.092

4.1.2. Section 2: Content of question

4.1.2.1. Gazing measures. The results of ANOVA showed no significant effect of AOIs. Because AOIs were defined as each food image on the testing picture, this demonstrates that there was no food image that attracted more attention than others.

In addition, no significant effect of *content of question* on the measured gazing behaviour parameters was found (Table 6 and Fig. 5). Thus, measured gazing behaviour parameters were not influenced by the *content of question*.

4.1.2.2. Decision time. The one-way ANOVA clearly showed no significant effect of the *content of question* on decision time at $p \leqslant 0.05$ (Table 7).

4.1.3. Section 3: Type of evaluation

4.1.3.1. Gazing measures. The results of ANOVAs showed no significant effect of AOIs. Again, this demonstrates that there was no image that attracted more attention than others.

Highly significant effects of the *type of evaluation* were found on all gazing behaviour parameters. Consumers fixated on testing images significantly longer and more often when performing a ranking or a grouping task in comparison with other tasks. Maximum choice task resulted in the shortest time of *fixation* and *visit duration*, and the lowest number of *fixation* and *visit counts* (Table 8 and Fig. 6).

4.1.3.2. Decision time. The decision time was significantly influenced by the *type of evaluation* (at $p \leqslant 0.05$). Maximum and minimum choice tasks appear to be easier than rating, ranking and grouping task. The grouping task seems to be the most difficult task and results in the longest decision time (Table 9 and Fig. 7).

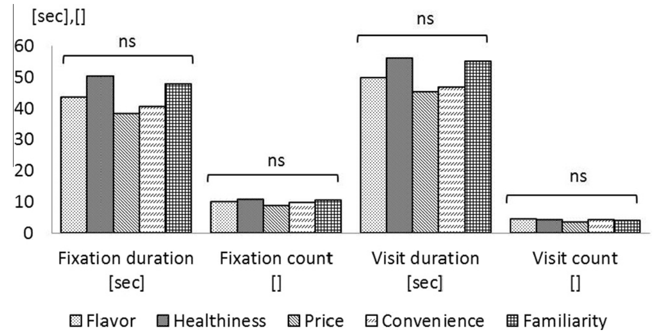

Fig. 5. Gazing behaviour parameters influenced by *Content of question* ^{ns} indicates no significant effect at $p \leqslant 0.05$.

Table 7
ANOVA results: *content of question – decision time.*

Variation	Time of decision		
	df	*F*-value	*p*-Value
Content of question	4	0.452	0.771

4.2. Experiment 2: the joint effect of influencing factors

4.2.1. Gazing measures

According to the results from the first experiment, the effects of the *number of images* and the *type of evaluation* were found. Hence, in the second experiment, the joint effect (interactions) between these two factors was investigated.

For data analysis, because AOIs were defined as the whole testing picture, the *visit count* was often one and no longer considered. As shown in Table 10, no significant joint effect of *number of images* and *type of evaluation* was found for all three gazing parameters (*fixation duration*, *fixation count,* and *visit duration*). These results suggest that each factor influences consumer gazing behaviour independently and there is no common synergistic or antagonistic effect.

4.2.2. Decision time

As shown in Table 11, no significant joint effect of the *number of images* and the *type of evaluation* was found for decision time. Again, each factor may influence the decision time independently.

5. Discussion

5.1. Effect of number of images

Highly significant effects of the *number of images* were found for *fixation count* and *visit duration* (at $p \leqslant 0.01$) and a slight effect for *fixation duration* (at $p \leqslant 0.1$). In fact, the more images there are, the

Table 6
ANOVA results: AOI and *content of question* – gazing behaviour.

Variation	Gazing behaviour parameters								
	df	Fixation duration		Fixation count		Visit duration		Visit count	
		F-value	*p*-Value	*F*-value	*p*-Value	*F*-value	*p*-Value	*F*-value	*p*-Value
AOIs	3	2.427	0.116	1.117	0.381	1.911	0.182	1.374	0.298
Groups: content of question	4	0.501	0.736	0.404	0.802	0.354	0.836	0.853	0.519

Table 8
ANOVA results: AOI and *type of evaluation* – gazing behaviour.

Variation	Gazing behaviour parameters								
	df	Fixation duration		Fixation count		Visit duration		Visit count	
		F-value	*p*-Value	*F*-value	*p*-Value	*F*-value	*p*-Value	*F*-value	*p*-Value
AOIs	3	1.118	0.380	0.710	0.565	0.764	0.536	0.633	0.588
Groups: type of evaluation	4	4.427	0.020	7.476	0.003	3.283	0.049	23.702	<0.001

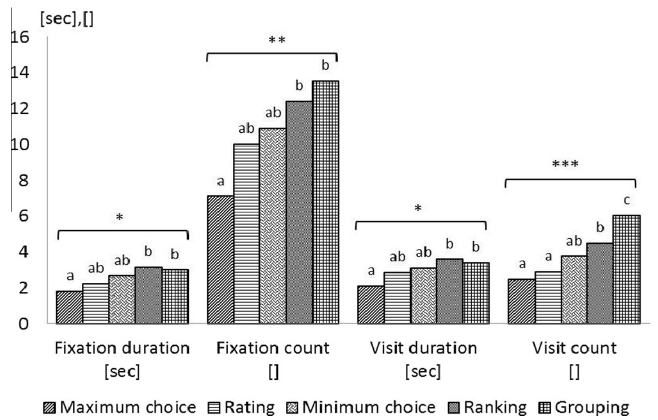

Fig. 6. Gazing behaviour parameters influenced by *Type of evaluation* * indicates significant effect at a significance level of $p \leqslant 0.05$; ** indicates significant effect at a significance level of $p \leqslant 0.01$; *** indicates significant effect at a significance level of $p \leqslant 0.001$.

Table 9
ANOVA results: *type of evaluation – decision time.*

Variation	Time of decision		
	df	*F*-value	*p*-Value
Type of evaluation	4	3.098	0.019

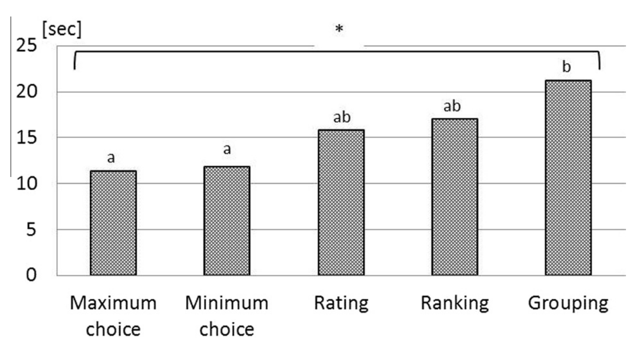

Fig. 7. *Decision time* influenced by *Type of evaluation* * indicates significant effect at a significance level of $p \leqslant 0.05$.

more time it takes to move the eyes between images. Hence, *fixation count* and *visit duration* increased strongly with the *number of images*, whereas *fixation duration* changed only slightly.

Considering that larger numbers of images per picture lead to a more complex information, our result is in line with the studies of Horstmann, Ahlgrimm, and Glöckner (2009), Lohse and Johnson (1996), Reutskaja, Nagel, Camerer, and Rangel (2011); and Russo and Dosher (1983). These studies showed an increase of the *fixation count* and a relative reduction of *fixation duration* on an average of AOIs fixated. As a result, total *fixation duration* measures increased only slightly with the complexity of information.

Table 10
ANOVA results: *type of evaluation, number of images* – gazing behaviour.

Variation	Gazing behaviour parameters						
	df	Fixation duration		Fixation count		Visit duration	
		F-value	*p*-Value	*F*-value	*p*-Value	*F*-value	*p*-Value
Type of evaluation	3	7.084	<0.001	9.845	<0.001	7.526	<0.001
Number of images/picture	2	11.757	<0.001	15.356	<0.001	12.837	<0.001
Interaction	6	0.558	0.763	1.491	0.184	1.421	0.209

Table 11
ANOVA results: *type of evaluation, number of images – decision time.*

Variation	Decision time		
	df	*F*-value	*p*-Value
Type of evaluation	3	9.914	<0.001
Number of images/picture	2	17.489	<0.001
Interaction	6	0.851	0.533

The decision time changed only slightly with the *number of images.* A decrease of the number of images per picture reduced cognitive efforts. However, no effect of cognitive effort reduction was found for decision difficulty. This is in line with studies from Beach and Mitchell (1978), Christensen-Szalanski (1978), and Russo and Dosher (1983), who assumed that motivation is adequate to overcome any effect of effort. In our study, the motivation was to select the healthiest product from several food products, which was found to be the easiest task (Fig. 7). The choice of the easiest task might be the reason that no effect of effort reduction on decision time was found. Our results support the findings of Russo and Dosher (1983), that cognitive effort is not conveniently separable from other task goals.

5.2. Effect of content of question

No effect of the *content of question* on consumer gazing behaviour was found. *Content of question* used in this study was related to different food aspects perceived by the consumers on different food images, but it did not influence their gazing behaviour.

Precedent studies about the effect of goal-specific motivation on consumer attention often address health motivation. Visschers, Hess, and Siegrist (2010) found that the respondents with a health motivation showed longer and more eye movements than respondents with a tastiness motivation. van Herpen and Trijp (2011) showed that health goals of consumers increase the attention to and the use of nutrition labels, especially when these health goals concern specific nutrients. More recently, Bialkova et al. (2014) found that a health goal resulted in longer and more frequent fixations than a preference goal. These studies were conducted on food packaging, especially on nutritional labels that is strongly related to health motivation. Therefore, these findings obviously cannot be transferred to studies of food products without packaging. In contrast, in the study of food products as such, health issues are, on average, no more important than other factors (Steptoe et al., 1995). Moreover, the evaluation in studies of food products (regardless of whether it concerns healthiness or tastiness) is more holistic and driven by unconscious factors than the evaluation of packaging with labels by reading, which is a verbal and more analytical process (part 6, Liversedge et al. (2011)).

Ares et al. (2013) observed different gazing behaviour when participants evaluated "perceived healthiness" and "willingness to purchase". "Willingness to purchase" is a more complex function related to a decision-making process than a perception of one independent characteristic of the product. The five contents of the questions in our study were related to main quality characteristics of the products and were selected to take similar memory and cognitive work to make a decision. Therefore, no effect of this factor was found on the decision time and gazing behaviour.

5.3. Effect of type of evaluation

Significant effects of the *type of evaluation* on all four gazing parameters were found. As predicted by several decision theories, eye movements are highly task dependent and linked to cognitive goals (Castelhano et al., 2009; Liversedge et al., 2011). Hence, changing the types of tasks resulted in a change of gazing behaviour. This result is in line with a number of previous studies. Several researchers replicated the original finding of Yarbus (1967): observing the same stimulus with different goals leads to different scan-paths (Glaholt et al., 2010; Glöckner et al., 2012; Kim et al., 2012).

The difficulty of a task is a consequence of the higher demand on working memory (Orquin & Mueller Loose, 2013). Difficulty was measured by decision time and changed following the *type of evaluation* (Fig. 7). Participants need different times to find the appropriate decision option, such as scanning alternatives in a forced choice task or comparing alternatives based on relevant attributes in a grouping task. As a result, the decision times of different tasks are clearly different. In previous studies, the task difficulty has been shown to have effects on consumer gazing behaviour, such as increasing the number of fixations (Fiedler & Glöckner, 2012; Glöckner & Herbold, 2011; Krajbich, Armel, & Rangel, 2010; Krajbich & Rangel, 2011). The influence of the *type of evaluation* on the difficulty of a task also explained why this factor influenced gazing behaviour.

5.4. Joint effects of test design factors

We did not find any joint effects of test design factors on consumer gazing behaviour or on decision time. Therefore, we propose the following tentative explanation for discussion. In fact, two tested factors possessed two different attention approaches. The *number of images* is a stimulus-driven-attention factor that reflects the bottom-up control of a cognitive process. The *type of evaluation* is a goal-driven-attention factor that reflects the top-down control of a cognitive process. Thus, it is understandable that we did not find any joint effect of these factors. This interpretation corroborates the finding that bottom-up control is mostly independent from top-down processes (Orquin & Mueller Loose, 2013).

5.5. Perspective

Further work should investigate the effect of complexity of the *content of question* on consumer attention, such as "willingness to try" a product. In case effects of *content of question* are found, whether there is a joint effect of *content of question* and *type of evaluation* should be examined. An argument for the existence of such an interaction may be that these two factors have the same attentional approach the goal-driven-attention. In addition, more diverse stimuli design factors (complexity of image, information level of image, etc.) and their interactions with other factors should be investigated in future studies. Similarly, other test design factors that define the difficulty of tasks need to be studied.

6. Conclusions

Our first two research questions, whether there is an influence of test design on consumer gazing behaviour and decision time in an eye-tracking test, are answered with the affirmative. Test design factors of an eye-tracking test clearly affected consumer gazing behaviour and decision time in different ways. In this study, consumer gazing behaviour was significantly influenced by the *type of evaluation* and the *number of images per picture* but not by the *content of question* relating to different aspects of the product. The effect of the *type of evaluation* on decision time reflected the task difficulty. The third research question, whether there is a joint effect of influencing test design factors on gazing behaviour and decision time, has been negated; we did not find any joint effect of the *number of images per picture* and the *type of evaluation* on gazing behaviour and decision time. These results have been discussed considering the relationship between eye-movements, cognitive goals, and tasks. This study highlights the importance of understanding factors influencing gazing behaviour in an eye-tracking test for a better application of this technique in studying consumer behaviour.

Acknowledgements

We are grateful to all participants in this study and thank to the department of Food Sciences and Technology, University of Natural Resources and Life Sciences, Vienna for financial support.

References

Ares, G., Giménez, A., Bruzzone, F., Vidal, L., Antúnez, L., & Maiche, A. (2013). Consumer visual processing of food labels: Results from an eye-tracking study. *Journal of Sensory Studies, 28*(2), 138–153.

Ares, G., Mawad, F., Giménez, A., & Maiche, A. (2014). Influence of rational and intuitive thinking styles on food choice: Preliminary evidence from an eye-tracking study with yogurt labels. *Food Quality and Preference, 31*, 28–37.

Beach, L. R., & Mitchell, T. R. (1978). A contingency model for the selection of decision strategies. *The Academy of Management Review, 3*(3), 439–449.

Bialkova, S., Grunert, K. G., Juhl, H. J., Wasowicz-Kirylo, G., Stysko-Kunkowska, M., & van Trijp, H. C. M. (2014). Attention mediates the effect of nutrition label information on consumers' choice. Evidence from a choice experiment involving eye-tracking. *Appetite, 76*, 66–75.

Bialkova, S., & van Trijp, H. C. M. (2011). An efficient methodology for assessing attention to and effect of nutrition information displayed front-of-pack. *Food Quality and Preference, 22*(6), 592–601.

Castelhano, M., Mack, M., & Henderson, J. (2009). Viewing task influences eye movement control during active scene perception. *Journal of vision, 9*(3), 1–15.

Christensen-Szalanski, J. J. J. (1978). Problem solving strategies: A selection mechanism, some implications, and some data. *Organizational Behavior and Human Performance, 22*(2), 307–323.

Corbetta, M., & Shulman, G. L. (2002). Control of goal-directed and stimulus-driven attention in the brain. *Nature Reviews Neuroscience, 3*(3), 201–215.

Duchowski, A. T. (2007). *Eye tracking methodology: theory and practice*. New York Inc: Springer-Verlag.

Fiedler, S., & Glöckner, A. (2012). The dynamics of decision making in risky choice: An eye-tracking analysis. *Front Psychology, 3*, 1–18.

Giel, K. E., Friederich, H.-C., Teufel, M., Hautzinger, M., Enck, P., & Zipfel, S. (2011). Attentional processing of food pictures in individuals with anorexia nervosa – An eye-tracking study. *Biological Psychiatry, 69*(7), 661–667.

Glaholt, M. G., Wu, M.-C., & Reingold, E. M. (2010). Evidence for top-down control of eye movements during visual decision making. *Journal of vision, 10*(5), 1–15.

Glöckner, A., Fiedler, S., Hochman, G., Ayal, S., & Hilbig, B. (2012). Processing differences between descriptions and experience: A comparative analysis using eye-tracking and physiological measures. *Front Psychology, 3*, 1–15.

Glöckner, A., & Herbold, A.-K. (2011). An eye-tracking study on information processing in risky decisions: Evidence for compensatory strategies based on automatic processes. *Journal of Behavioral Decision Making, 24*(1), 71–98.

Graham, R., Hoover, A., Ceballos, N. A., & Komogortsev, O. (2011). Body mass index moderates gaze orienting biases and pupil diameter to high and low calorie food images. *Appetite, 56*(3), 577–586.

Graham, D. J., & Jeffery, R. W. (2012). Predictors of nutrition label viewing during food purchase decision making: An eye tracking investigation. *Public Health Nutrition, 15*(2), 189–197.

Graham, D. J., Orquin, J. L., & Visschers, V. H. M. (2012). Eye tracking and nutrition label use: A review of the literature and recommendations for label enhancement. *Food Policy, 37*(4), 378–382.

Hepworth, R., Mogg, K., Brignell, C., & Bradley, B. P. (2010). Negative mood increases selective attention to food cues and subjective appetite. *Appetite, 54*(1), 134–142.

Hess, E. H., & Polt, J. M. (1964). Pupil size in relation to mental activity during simple problem-solving. *Science, 143*(3611), 1190–1192.

Horndasch, S., Kratz, O., Holczinger, A., Heinrich, H., Hönig, F., Nöth, E., et al. (2012). "Looks do matter" – Visual attentional biases in adolescent girls with eating disorders viewing body images. *Psychiatry Research, 198*(2), 321–323.

Horstmann, N., Ahlgrimm, A., & Glöckner, A. (2009). How distinct are intuition and deliberation? An eye-tracking analysis of instruction-induced decision modes. *Judgment and Decision Making, 4*(5), 335–354.

Jantathai, S., Danner, L., Joechl, M., & Dürrschmid, K. (2013). Gazing behavior, choice and color of food: Does gazing behavior predict choice? *Food Research International, 54*(2), 1621–1626.

Jones, G. (2003). Testing two cognitive theories of insight. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29*(5), 1017–1027.

Kim, B., Seligman, D., & Kable, J. W. (2012). Preference reversals in decision making under risk are accompanied by changes in attention to different attributes. *Frontiers in Neuroscience, 6*, 1–10.

Knoblich, G., Ohlsson, S., & Raney, G. (2001). An eye movement study of insight problem solving. *Memory & Cognition, 29*(7), 1000–1009.

Krajbich, I., Armel, C., & Rangel, A. (2010). Visual fixations and the computation and comparison of value in simple choice. *Nature Neuroscience, 13*(10), 1292–1298.

Krajbich, I., & Rangel, A. (2011). Multialternative drift-diffusion model predicts the relationship between visual fixations and choice in value-based decisions. *Proceedings of the National Academy of Sciences, 108*(33), 13852–13857.

Liversedge, S., Gilchrist, I., & Everling, S. (2011). *The oxford handbook of eye movements*. Oxford: OUP.

Lohse, G. L., & Johnson, E. J. (1996). A comparison of two process tracing methods for choice tasks. *Organizational Behavior and Human Decision Processes, 68*(1), 28–43.

Milosavljevic, M., Navalpakkam, V., Koch, C., & Rangel, A. (2012). Relative visual saliency differences induce sizable bias in consumer choice. *Journal of Consumer Psychology, 22*(1), 67–74.

Mitterer-Daltoé, M. L., Queiroz, M. I., Fiszman, S., & Varela, P. (2014). Are fish products healthy? Eye tracking as a new food technology tool for a better understanding of consumer perception. *LWT – Food Science and Technology, 55*(2), 459–465.

Orquin, J. L., & Mueller Loose, S. (2013). Attention and choice: A review on eye movements in decision making. *Acta Psychologica, 144*(1), 190–206.

Piqueras-Fiszman, B., Velasco, C., Salgado-Montejo, A., & Spence, C. (2013). Using combined eye tracking and word association in order to assess novel packaging solutions: A case study involving jam jars. *Food Quality and Preference, 28*(1), 328–338.

Rebollar, R., Lidón, I., Martín, J., & Puebla, M. (2015). The identification of viewing patterns of chocolate snack packages using eye-tracking techniques. *Food Quality and Preference, 39*, 251–258.

Reutskaja, E., Nagel, R., Camerer, C. F., & Rangel, A. (2011). Search dynamics in consumer choice under time pressure: An eye-tracking study. *American Economic Review, 101*(2), 900–926.

Russo, J. E. (1978). Eye fixations can save the world: A critical evaluation and a comparison between eye fixations and other information processing methodologies. *Advances in Consumer Research, 05*, 561–570.

Russo, J. E., & Dosher, B. A. (1983). Strategies for multiattribute binary choice. *Journal of experimental psychology. Learning, memory, and cognition, 9*(4), 676–696.

Siegrist, M., Leins-Hess, R., & Keller, C. (2015). Which front-of-pack nutrition label is the most efficient one? The results of an eye-tracker study. *Food Quality and Preference, 39*, 183–190.

Steptoe, A., Pollard, T. M., & Wardle, J. (1995). Development of a measure of the motives underlying the selection of food: The food choice questionnaire. *Appetite, 25*(3), 267–284.

van Herpen, E., & Trijp, H. C. M. V. (2011). Front-of-pack nutrition labels. Their effect on attention and choices when consumers have varying goals and time constraints. *Appetite, 57*(1), 148–160.

Visschers, V. H. M., Hess, R., & Siegrist, M. (2010). Health motivation and product design determine consumers' visual attention to nutrition information on food products. *Public Health Nutrition, 13*(7), 1099–1106.

Werthmann, J., Roefs, A., Nederkoorn, C., & Jansen, A. (2013). Desire lies in the eyes: Attention bias for chocolate is related to craving and self-endorsed eating permission. *Appetite, 70*, 81–89.

Yarbus, A. L. (1967). *Eye movements and vision*. New York: Plenum Press.