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Gazing behavior, choice and color of food: Does gazing behavior predict choice?

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ABSTRACT

This study investigated the effect of food color on gazing behavior using eye-tracking technology and the correlation between gazing behavior and choice decision. Tobii T60 eye-tracker was used for analyzing the gazing behavior of consumers. Images of three different food products with three different colors each (yellow, green, pink) were used as stimuli. Seventy-three subjects were recruited; color blind individuals were excluded from the test. After the eye tracking procedure, the test persons had to decide which sample they preferred. Results show that the colors of the used food products significantly affected the gazing behavior and the choice. Fixation count and visit duration correlated significantly in a positive way with choice rate. This insight highlights the importance of visual attraction for the choosing behavior and it might open the chance to predict choice behavior measuring gazing behavior.

1. Introduction

Colors of food products have a high impact on visual preferences (Kildegaard, Olsen, Gabrielsen, Moller, & Thybo, 2011). The "first taste" in human is created based on the visual cues when gazing at food items (Clydesdale, 1991; de Wijk, Polet, Engelen, Vandoorn, & Prinz, 2004; Imram, 1999; Jaros, Rohm, & Strobl, 2000). Food color might influence the choosing behavior by eliciting certain expectations and feelings of appropriateness, but it also might modulate the gazing behavior, which itself might have an impact on decision making. Armel, Beaumel, and Rangel (2008) found that the relative amount of time that subjects fixated an item during a decision-making process increases the probability that the item will be chosen. The gazing behavior individuals pay to items like food products can be investigated using eye tracking technology (Gofman, Moskowitz, Fyrbjork, Moskowitz, & Mets, 2009). This method studied gazing behavior by inspecting eye movement and monitoring the focus of gazing behavior, based on defined areas of interest (AOI) within a visual stimulus (Salvucci & Goldberg, 2000). Important aspects of monitoring eye activities during respondents' viewing are where people's attention is attracted, how long the fixation position is captured within a defined region but also how often the AOI is revisited, and the time to first fixation (Henderson & Hollingworth, 1998).

Visual tracking technology can possibly be useful for receiving vital information about non-verbal and implicit reactions of consumers towards food objects. Gofman et al. (2009) used the so called "hot spot" technique to analyze the effect of several dimensions of packages such as font size, colors and locations of images on capturing the gazing behavior of the viewing individual. Moreover, Bialkova and van Trijp (2011) used to assess attention to information cues displayed front-of-pack. The attention bias of the eye movement and reaction time of overweight and normal-weight subjects to food and non-food images was studied by Castellanos et al. (2009). They found that both groups of subjects increased gaze duration for food compared to non-food images. Duerrschmid, Wallner, and Kneifel (2009) and Graham, Hoover, Ceballos, and Komogortsev (2011) studied the impact of low and high-calorie food images on gaze responses of normal weight and overweight women. Both groups did not differ in the average amount of time spent gazing at the different regions of the presented visual food stimuli. Haindl and Duerrschmid (2010) presented an U- or inverted U-model for the relations between eye tracking parameters and food quality status. Results revealed that spoiled products even attracted more attention than fresh food products.

To our knowledge of literature on consumers' eye movement pattern using eye tracking technology, there are few publication involving the effects of food coloration on gazing and choice behavior of consumers. Our experiment investigated the effects of color on consumers' gazing behavior and their choice decision. Images of food objects (desserts with three different colors each) were used as stimuli. A focus was laid on the relationship between gazing and choosing behavior. Therefore, three research questions had to be answered: (1) Does the

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color of food samples have an impact on gazing parameters? (2) Does the color of samples have a significant impact on the choosing behavior? (3) Is there a relation between gazing behavior parameters and choosing behavior?

2. Materials and methods

2.1. Subjects

Sixty males and fifty-eight females (students or staff at the University of Natural Resources and Life Sciences in Vienna) participated in this study. Subjects suffering from any kind of color blindness or subjects failing in the eye tracking calibration procedure were excluded. Detecting color blindness the method of Velhagen and Broschmann (2003) was used. For calibration procedure, subjects had to follow a red dot on the screen with their eyes. The dot was moving from the screen center to the corners. This procedure allows the eye tracker to adjust the analysis algorithm to the specific eye configuration of the tested individual. The final number of subjects was 37 males and 36 females; they passed calibration and their data showed eye tracker recording quality over 75%. Their age ranged from 18 to 50 with a mean age of 26.3 ± 5.6 years.

The study was performed in appliance with the ethical guidelines for scientific research of University of Natural Resources and Life Sciences, Vienna. The subjects were informed about the testing procedure before the test and about the aims of the experiment after the test with the option to delete the data, if the test person would not agree to participate in a test with these aims; all test persons gave a written informed consent.

2.2. Stimuli

Three kinds of Thai desserts were prepared freshly for taking the eye tracking pictures (product 1–3). The main ingredients of each dessert are listed in Table 1. Colors and their concentrations used in the formulas were selected based on traditions of preparation. Artificial colorants (Winner brand, Thailand) used in all samples were green, pink and yellow. Colorant concentrations used for yellow and green were 0.1% (w/v) and that for pink was 0.05%. Images of each sample were taken with a Canon EOS 400D digital camera after preparation. Images were placed on a white plate in front of a black background; the samples were adjusted for scale, contrast and color using Adobe Photoshop CS5.

2.3. Color measurement

Colors of all samples were measured by using a LMG051 Micro Color (Dr. Lange, Düsseldorf, Germany). In the CIELAB system, L^* indicates degree of lightness or darkness ($L^* = 0$ indication perfect black and $L^* = 100$ indicating perfect white); a^* and b^* indicate degree of redness or greenness and yellowness or blueness, respectively and chroma (C^*) indicates degree of color saturation and is equal to zero at the center of the color space and increases based on the distance from the center (Lawless & Heymann, 2010).

2.4. Testing procedure

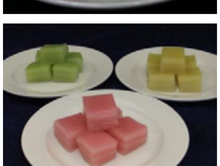
The Tobii T60 eye tracking device and Tobii Studio software (version 3.0.5, Tobii Technology AB, Sweden) were used for recording and analyzing the gazing behavior of consumers. The stimulus images of the dessert products were shown on the eye tracking monitor (17 in., 1280×1024 pixel resolution). Subjects took a seat in front of the eye tracker screen with their face at a distance of approximately 70 cm. They were instructed to look at the pictures at the monitor in a relaxed way and not to move too much. Each test started with an instruction text on the screen. In order to define the starting point of gazing, a central fixation cross was displayed between the instruction texts and also between the following food images for two seconds. Pictures of the three color variants of one product were shown separately with a display time for eight seconds to highlight visual appearance. Then, an image containing all three color variants of this product on three different positions (left, right and bottom) were displayed for 15 s (see Fig. 1 for an example). The position of the color variants was randomized for subjects. This was repeated for all three products.

After completing the eye-tracking procedure, subjects were asked to look at food images on the monitor showing the three differently colored products (green, pink, and yellow) and to choose the most preferred color variant for each product.

2.5. Data analysis

All statistical analyses were performed using SPSS version 21 for Windows (IBM Corporation, Armonk, USA). Five parameters of gazing behavior were collected: 1) *time to first fixation* (TFF, the time from the start of the media display until the test participant fixated on the area of interest (AOI) [seconds]), 2) *first fixation duration* (FFD, duration

Table 1
Thai desserts used in this study.

	Sample	Characteristics	Ingredient	Cooking method
	Product 1 (*Pui-fai*)	This is a muffin-style dessert with 3 to 4 cracks on the surface. Taste is sweet and texture is very soft.	Wheat flour (34%), condenser milk (12%), baking powder (1%), water (19%), emulsifier (3%), egg (3%) and sugar (30%)	Steam at 95 °C, 25 min
	Product 2 (*Khao-naeow-gaow*)	Sticky rice, which is sweet and has a coconut flavor.	Glutinous rice (62%), coconut milk (17.50%), salt (0.5%) and sugar (20%)	Heated stir at 50 °C, 20 min
	Product 3 (*Kha-nom-shun*)	It is usually made of nine layers, white ones alternating with layers of another color. Taste is sweet, texture is smooth and sticky.	Tapioca flour (12.50%), corn flour (3.75%), rice flour (3.75%), coconut milk (37.50%), water (13.75%) and sugar (28.75%)	Steam at 95 °-C, 15 min a layer

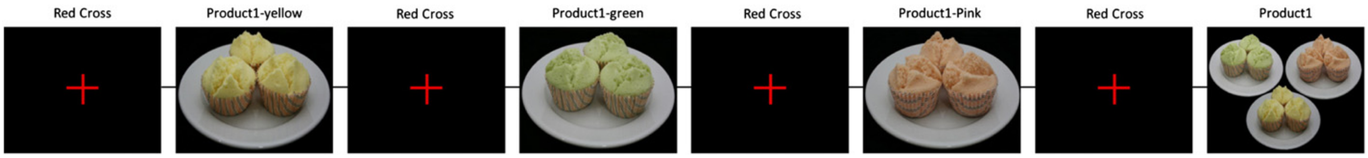


Fig. 1. Example of the ordering the food picture.

of the first fixation on an AOI [seconds]), 3) *fixation duration* (FD, duration of each individual fixation within an AOI [seconds]), 4) *fixation count* (FC, number of times the participant fixates on an AOI [count]) and 5) *visit duration* (VD, duration of each individual visit with an AOI [seconds]). A multivariate analysis of variance (MANOVA) was performed to test differences in the color parameter between samples. For each product, a MANOVA was used to examine the effect of colors (green, pink, yellow) and sample position (left, right, bottom) on the five gazing behavior parameters. In case the MANOVA showed significant effects, univariate and Duncan's post-hoc tests were performed. Chi-square (χ^2) test was conducted to examine the relationship between fixation count and choice rate as well as between visit duration and choice rate. To highlight the relation between gazing behavior and choosing behavior we ranked the gazing behavior parameters (fixation count and visit duration) for each product and individual in low, medium and high fixation count and also visit duration. Then we calculated the number of individuals which gaze at the three products variants with a low, medium and high value of fixation count and visit duration (Figs. 4 and 6). Additionally, a chi-square (χ^2) test of independence was used to examine the effect of color on choice decision.

3. Results

3.1. Results of the choice test

Fig. 2 presents the numbers of choices for the three different color variants of the three products. There are highly significant differences within product 1 (df = 2, $\chi^2 = 27.658$; $p < 0.001$) and within product 2 (df = 2, $\chi^2 = 17.548$; $p < 0.001$). The yellow product 1 variant was chosen more often, then the pink and green counterparts (56.2%, 27.4%, and 16.4%, respectively). For product 2, the yellow and the green variants were more often chosen than the pink variant (46.6%, 38.4%, and 15.1%, respectively). For product 3, a different trend was found (df = 2, $\chi^2 = 5.096$; $p < 0.1$), the green and pink variants were chosen with almost equal frequency and significantly more often than the yellow variant (39.7%, 37.0%, and 23.3%, respectively).

3.2. Results of the gazing behavior measurements

The influence of different colors (green, pink, and yellow) of three different desserts on the five gazing behavior parameters (time to first fixation, first fixation duration, fixation duration, fixation count, and visit duration) was analyzed using MANOVA. There were no significant differences for the time to first fixation and first fixation duration between the three colors for all three products. In contrast, the fixation count and visit duration differed significantly (Table 2). The mean values of fixation count for yellow, pink and green of product 1 were 13.35, 11.20, and 9.73, respectively. The visit duration of those products showed a similar trend (4.97, 3.66, and 3.36, respectively). The yellow product 2 was significantly higher in fixation count (12.44) and visit duration (4.82) than the green and the pink variant. In contrast, both fixation count and visit duration of product 3 with white-pink color gave higher values compared to other colors (12.66 for fixation count and 4.43 for visit duration).

As shown in Table 3, a significant effect of the positions (left, right and middle) on gazing behavior was only found for time to first fixation on product 1 ($p = 0.002$). For all the other gazing behavior parameters and the other products, we could not find significant effects of the position of the product. No significant interaction between the position and the color was observed.

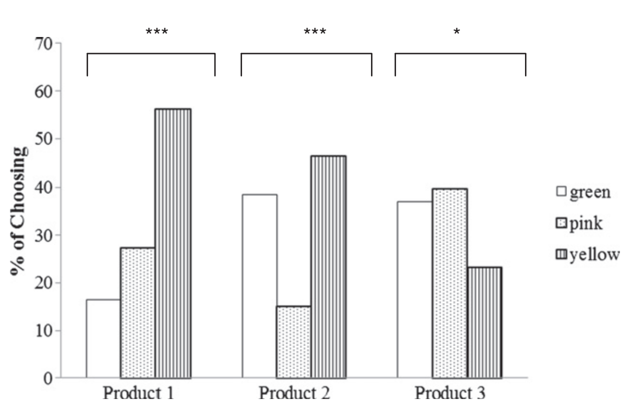


Fig. 2. Results of the choice test (*$p < 0.1$, ***$p < 0.001$).

3.3. Relationships between gazing parameters and choice rates

The two gazing parameters that showed significant differences in the ANOVA (fixation count, visit duration) were analyzed in their relationship to choice rates. The mean values of fixation count for each color-variant of the three products were plotted against the number of choices (see Fig. 3). A significant positive correlation between fixation count and choice decision was found for all three investigated products. Due to the differences between subjects in gazing behavior, the data of fixation count of participants were grouped into low, medium, and high fixation counts for each subject (Fig. 4). Products with high fixation count numbers were chosen more often than products low in fixation count. The frequency of choosing the group of high fixation count for product 1 was approximately three times higher than that of low fixation group. Similarly, results of products 2 and 3 showed the same trends. Chi-squared test indicated that the relationship between fixation count and number of choices was significant for product 1 ($\chi^2_{MH} = 15.918$, $p < 0.001$), product 2 ($\chi^2_{MH} = 4.748$, $p = 0.029$) and product 3 ($\chi^2_{MH} = 5.855$, $p = 0.016$).

Figs. 5 and 6 show the differences in choice rate related to visit duration. These results show a similar pattern as the fixation count data. However, a significant correlation was revealed only for product 1 ($\chi^2_{MH} = 12.442$, $p < 0.001$), whereas products 2 and 3 were not significant on $\alpha = 0.05$ level with $\chi^2_{MH} = 2.485$, $p = 0.115$ and $\chi^2_{MH} = 3.712$, $p = 0.054$, respectively (Fig. 6).

4. Discussion

Our investigations show that color has a significant influence on visit duration, which is consistent with the findings of Kildegaard et al. (2011). However, no significant effect of color on time to first fixation, first fixation duration and fixation duration was observed, this is in agreement with Bialkova and van Trijp (2011). Giel et al. (2011) reported that the initial fixation duration did not give any evidence for an attention orienting bias. Thus, number of fixations and the duration of gaze indicate the maintenance or engagement of attention (Armel et al., 2008; Field, Mogg, & Bradley, 2004; Krajbich & Rangel, 2011). Our results corroborate these findings to a broad extent.

Table 2
Multivariate analysis of variable (MANOVA) of the color measurement data and the gazing behavior data of untrained subjects (n = 73).

Parameter	Product 1			Product 2			Product 3		
	Green	Pink	Yellow	Green	Pink	Yellow	Green	Pink	Yellow
Color measurement									
L^*	89.67 ± 0.64^a	86.20 ± 1.92^b	89.57 ± 1.00^a	69.87 ± 2.72^a	62.03 ± 4.67^b	72.13 ± 2.51^a	51.70 ± 1.77^b	47.70 ± 0.44^c	54.97 ± 1.83^a
a^*	-7.13 ± 0.64^c	15.70 ± 1.20^a	2.80 ± 0.44^b	-3.63 ± 0.25^c	13.90 ± 0.95^a	-1.60 ± 0.53^b	-4.33 ± 0.11^c	4.53 ± 0.15^a	-2.37 ± 0.15^b
b^*	29.47 ± 0.59^a	13.20 ± 2.07^c	18.47 ± 0.78^b	21.30 ± 0.66^a	3.63 ± 0.97^c	10.57 ± 0.55^b	13.47 ± 1.14^a	-4.13 ± 0.06^c	6.90 ± 0.20^b
$h°$	-76.41 ± 0.95^c	39.93 ± 1.00^b	81.35 ± 1.51^a	-80.30 ± 0.95^b	14.52 ± 1.00^a	-81.31 ± 1.25^b	-72.10 ± 1.02^b	-42.37 ± 1.29^a	-71.05 ± 1.50^b
C°	30.32 ± 0.71^a	20.58 ± 1.07^b	18.68 ± 0.74^c	21.6 ± 0.60^a	14.38 ± 1.13^b	10.70 ± 0.47^c	14.14 ± 1.11^a	6.14 ± 0.08^b	7.29 ± 0.15^b
Gazing behavior									
TFF^{ns}	1.44 ± 1.15	0.95 ± 0.79	1.02 ± 0.75	1.27 ± 0.94	1.27 ± 1.20	1.18 ± 1.11	1.23 ± 1.10	1.07 ± 0.82	1.16 ± 0.99
FFD^{ns}	0.87 ± 0.62	0.30 ± 0.25	0.40 ± 0.26	0.27 ± 0.15	0.35 ± 0.30	0.28 ± 0.13	0.31 ± 0.13	0.30 ± 0.14	0.32 ± 0.15
FD^{ns}	0.33 ± 0.15	0.31 ± 0.09	0.36 ± 0.13	0.33 ± 0.13	0.33 ± 0.19	0.37 ± 0.22	0.31 ± 0.10	0.34 ± 0.10	0.35 ± 0.11
FC	9.73 ± 5.37^b	11.20 ± 5.13^b	13.35 ± 4.65^a	10.59 ± 4.30^b	10.45 ± 4.77^b	12.44 ± 5.14^a	11.07 ± 5.42^b	12.66 ± 5.19^a	9.41 ± 3.07^c
VD	3.36 ± 1.90^b	3.66 ± 1.61^b	4.97 ± 2.08^a	3.72 ± 1.59^b	3.46 ± 1.46^b	4.82 ± 2.25^a	3.77 ± 2.01^b	4.43 ± 1.77^a	3.62 ± 1.54^b

For each product type means within a row with different letters are significantly different ($p < 0.05$) according to Duncan's test; ns = not significant differences.
TFF = Time to first fixation, FFD = First fixation duration, FD = Fixation duration, FC = Fixation count, VD = Visit duration.

Our experiments also revealed that all color variants with the highest fixation count and visit duration had the lowest chroma values (Table 2). It has to be considered that these results are derived from only three products in three color variants. Further research has to examine whether this finding can be generalized. Just considering the samples of our experiments indicates that Austrian consumers would prefer desserts with low saturated color. Maybe an explanation for this finding is that consumers are concerned by food additives used to enhance color attraction. A growing percentage of consumers prefer healthy natural food products with less color additives. Consumers in Europe seem to show negative attitudes to food additives in general and visible additives in particular (Hutchings, 2003). Additionally, Wei, Ou, Luo, and Hutchings (2012a) found that orange juice samples with highly saturated colors were expected to have a strong flavor. The reason for this may be that this is the natural color for orange juice.

Significant differences in gazing behavior and choosing rates regarding color variant were observed between the three products. The ingredients, colorants and the resulting appearance might play a significant role in consumer attention and choice. The appearance and ingredients of product 1 with yellow color are similar to cupcake or muffins sold in Austria. According to Hutchings (2003) yellow color is associated with desserts containing egg and condensed milk as main ingredient. Similarly, product 2 with yellow color was often chosen over other colors due to perception of its main ingredient, sticky rice, which is recognized as white color. Therefore, the yellow variant of product 2 showing the most similar appearance to normal rice was the most attractive. However, the appearance of product 3 was different from those of product 1 and product 2, because of its specific design. Product 3 is composed of nine layers of five colored and four white gelatinized starch layers. When white and colored layers are laid closely they may cause a contrast effect on consumer vision thus increasing eye attraction. Hutchings (2003) mentioned that contrast effects change the appearance of color placed alongside another color.

Past experience, appreciation of sensory properties, intentions, and expectations are usually used to predict the behavior of food choice (Köster, 2009). The color of products is closely related to expectations — it often serves as a quality cue — and also plays an important role in remembering past experiences. Additionally, it can attract consumers' eyes thereby influencing their choosing behavior. Consumers tend to prefer the colors of products that match with their memories (Wei, Ou, Luo, & Hutchings, 2012b). Our experiments examined the effect of colors on gazing and choice behavior without tasting, smelling or touching the food. This is a situation which is very common e.g. in supermarket situations, where consumers can see the food products as images on the packaging, but are not able to perceive them with other senses than vision. Of course, choice behavior can be changed after tasting the food samples, the

Table 3
The effect of the position and the color on gazing behavior obtained by MANOVA (n = 73).

Variation			**Product 1**			**Product 2**			**Product 3**		
		df	MS	F	*p*	MS	F	*p*	MS	F	*p*
Color (C)	TFF	2	0.319	0.314	0.731	0.135	0.114	0.892	0.568	0.593	0.554
	FFD	2	0.303	0.066	0.333	0.073	1.324	0.269	0.010	0.478	0.621
	FD	2	0.025	2.263	0.107	0.047	1.295	0.276	0.043	2.523	0.083
	FC	2	170.125	6.638	0.002	73.233	3.167	0.045	172.181	7.881	0.001
	VD	2	39.888	11.292	0.000	29.626	8.873	0.000	11.857	3.734	0.026
Position (P)	TFF	2	6.833	6.717	0.002	1.850	1.567	0.212	2.126	2.218	0.111
	FFD	2	0.054	0.910	0.404	0.044	0.786	0.457	0.010	0.452	0.637
	FD	2	0.008	0.743	0.477	0.002	0.065	0.937	0.012	0.727	0.485
	FC	2	35.949	1.403	0.249	3.421	0.148	0.863	19.713	0.902	0.407
	VD	2	7.855	2.224	0.111	0.019	0.006	0.994	7.074	2.228	0.110
C x P	TFF	4	1.761	1.731	0.145	1.605	1.359	0.250	0.437	0.456	0.768
	FFD	4	0.055	0.924	0.451	0.026	0.477	0.752	0.010	0.448	0.774
	FD	2	0.016	1.440	0.222	0.032	0.886	0.473	0.020	1.189	0.317
	FC	4	20.290	0.792	0.532	10.222	0.442	0.778	29.193	1.336	0.258
	VD	4	1.247	0.353	0.842	1.896	0.568	0.686	1.968	0.620	0.649

The numbers with gray color are significantly different ($p < 0.05$) according to Duncan's test.
TFF = time to first fixation, FFD = first fixation duration, FD = fixation duration, FC = fixation count, VD = visit duration.

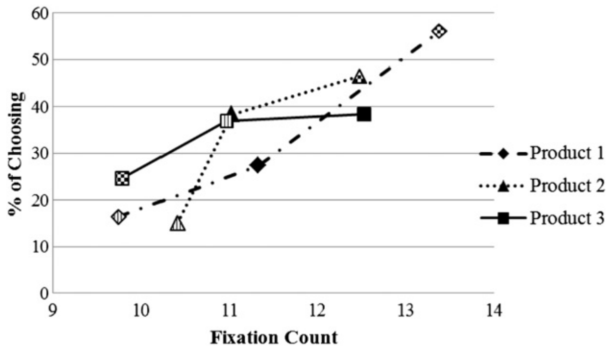


Fig. 3. Relationship between fixation count and number of choice products (the mark with line indicates green sample, the mark with black indicates pink sample, and the mark with black & white indicates yellow sample).

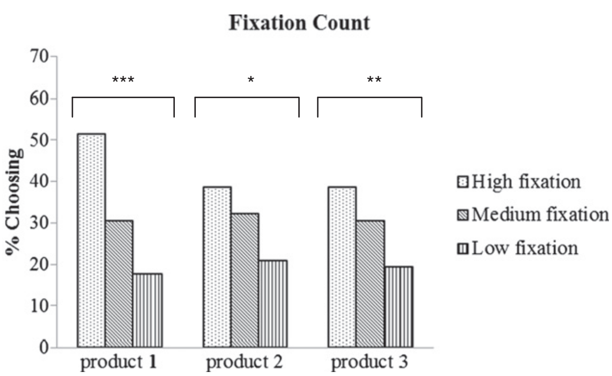


Fig. 4. Relationship between the ranking number of fixation and the number of choice: $^{*}p < 0.1$, $^{**}p < 0.01$, $^{***}p < 0.001$, n.s. = not significant).

appearance quality cues may be misleading. To evaluate the influence of visual and other sensory perceptions on gazing behavior and choice further studies are necessary.

Previous research reported that the relative amount of time that subjects fixated on an item during a decision making process increased the probability of choosing (Armel et al., 2008). Similarly, our results showed a clear positive correlation between choice rate and the gazing behavior parameters (fixation count and visit duration). Products high in fixation counts and visit duration had a higher choosing probability. The gazing behavior parameters fixation count and visit duration could be used to predict the choice rate reasonably. Prior studies also reported that relative fixation time was significantly correlated with choice (Krajbich, Armel, & Rangel, 2010; Lim, Doherty, & Rangel, 2011). Lim et al. (2011) suggested also that participants overtly switched their eye fixations to left and right during the choice process.

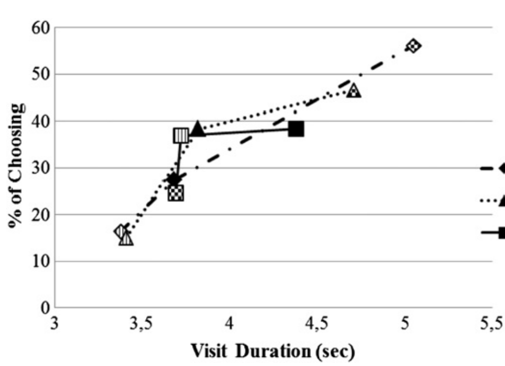


Fig. 5. Relationship between visit duration and choice number products (the mark with line indicates green product, the mark with black indicates pink product, and the mark with black & white indicates yellow product).

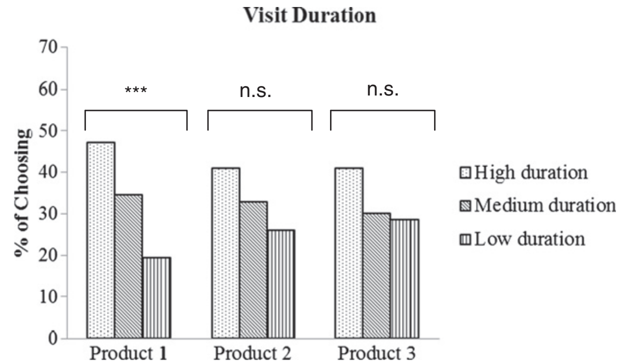


Fig. 6. Relationship between the ranking of visit duration and the number of choice ($^{**}p < 0.01$, n.s. = not significant).

The attended item was passed to both hemispheres, while the unattended item was passed only to the contralateral hemisphere. They suggested that the individual's gaze shifted repeatedly between the items until one of them was finally selected. Krajbich et al. (2010) investigated the role of gazing behavior on binary choice. They found that the probability of choosing increases with the increasing time of fixation, which also corroborates our findings. In our experiments, we used three differently colored product variants for one eye tracking and choice test. In future experiments we will use more than three samples in one picture, and also different product categories; color parameters of the products will be varied in a factorial design experiment. We speculate that a higher number of samples within one eye tracking and choice test will make the relationship between gazing and choice behavior even clearer.

5. Conclusions

By using eye tracking technology for effectively monitoring gazing behavior, our experiments revealed that by using three colors (pink, green, yellow) and three products sample color significantly influenced gazing behavior of consumers. No significant effect of sample position was found. Since there were significant positive correlations between two eye tracking parameters (fixation count and visit duration) and the choice rate, the parameters fixation count and visit duration could further be investigated and discussed as predictors of consumers' choice.

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