MAKE A CHOICE! VISUAL ATTENTION AND CHOICE BEHAVIOR IN MULTIALTERNATIVE FOOD CHOICE SITUATIONS

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Abstract

This study investigates the relationship between gazing behavior and choice decision in multialternative forced choice tasks, focusing on the consistency across different food product groups including apple, beer, bread, chocolate, instant soup, salad, sausage and soft drink. Each choice task consisted of pictures of four alternatives, similar in familiarity and liking ratings, of the corresponding product group. A Tobii T60 eye-tracker was used to present the stimuli and to analyze the gazing behavior of 59 participants during decision-making.

The results showed strong correlations between choice and gazing behavior, in forms of more fixation counts, longer total dwell duration and more dwell counts on the chosen alternative. No correlations for first fixation, time to first fixation and first fixation duration were observed. These results were consistent across the eight tested product groups.

Keywords: food choice, eye-tracking, multialternative choice situation, choice prediction

Food choices are complex behaviors that are determined by many factors, including intrinsic product characteristics, biological, physiological, psychological, situational, sociocultural

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factors and extrinsic product characteristics and the interaction between them (KÖSTER, 2009). "The first taste is almost always with the eye" (IMRAM, 1999), triggering expectations, memories, emotions *etc*., consequently the visual perception is a vital component of total food quality perception and significantly influences food choice (JAROS et al., 2000; VAN DER LAAN et al., 2011).

Most published studies examined gazing behavior in a food or nutritional context, with a special focus on package design and food labels (BIALKOVA & VAN TRIJP, 2011; ARES et al., 2013; ARES et al., 2014). For a review regarding eye-tracking and nutrition label use see GRAHAM and co-workers (2012).

"Not seen, not bought" is a well-known proverb of marketing experts. This raises the question how choice in general and especially food choice, product properties and visual attention are associated. It has been demonstrated across different tasks that several gazing parameters are correlated with choice decisions. For a recent literature review on eye movements in decision-making, see ORQUIN and MUELLER LOOSE (2013). Summarizing several eye-tracking studies they found that participants tend to have more fixations on the alternative they choose, a greater number of dwells and longer total dwell duration (dwell duration is defined as the sum of fixation durations made to a stimulus before the decision maker fixates another area). Furthermore, they stated that it is very likely that decision makers have their last fixation on the chosen alternative and likely that the first fixated alternative is the chosen one.

Although the correlation between choice and gazing behavior has been studied for some time, only a few studies focused on food choice in particular (KRAJBICH & RANGEL, 2011; REUTSKAJA et al., 2011; JANTATHAI et al., 2013; ARES et al., 2014) and if the gazing behavior is consistent across different food categories.

Concluding literature, there appears to be a lack of evidence showing how consistent the correlations between gazing behavior and choice are across different food product groups. Hence, the aim of this study was to examine the correlations between gazing behavior aspects and choice over eight different food product groups, resulting in the following hypotheses:

H1: The chosen food product receives more visual attention in form of a) fixation counts b) total dwell duration and c) dwell counts.

H2: The first fixated product is more likely to be chosen than its alternatives.

H3: The last fixation before the decision is on the chosen product.

In case significant relations between choice and gazing behavior parameters are found it is of special interest how consistent they are, comparing the different food product groups and how accurate these gazing parameter can predict choice, resulting in hypotheses 4.

H4: The relationship between gazing behavior and choice is consistent for different food product groups.

1 Material and methods

1.1 Visual Stimuli

Food products of "everyday" life, which are very familiar to the participants and have moderate visual complexity (no complex dishes), were chosen as possible stimuli. The selection of the final choice-sets and product pictures was based on a pretest with 40 participants (similar age as the participants of the main test; students aged between 18 and 28, equal gender distribution) investigating consumers familiarity, liking and visual appearance of a wide range of products. The pretest resulted in 9-choice sets consisting of 4 pictures comparable in (high) familiarity, liking and appealing visual appearance. Special care was taken to select pictures in good quality, comparable lightening and size. One choice out of the nine choice sets was used as a warm-up

to familiarize the participants with the procedure and was not included in the data analysis. The remaining eight choice sets represented different product categories including apple, beer, bread, chocolate, instant soup, salad, sausage and soft drink (Figure 1).

Figure 1 about here

1.2 Eye-tracking procedure

The same multi-alternative forced choice test paradigm (4AFC) without time limit as presented in the study by GERE et al. (2016) was used. 59 students of the University of Natural Resources and Life Sciences Vienna (BOKU) participated in the study (29 male, 30 female; aged between 18 and 28). A Tobii T60 eye-tracker and Tobii Studio software (version 3.0.5, Tobii Technology AB, Sweden) were used for presenting the stimuli, recording and analyzing the gazing behavior of the 59 participants during the choice task. The experiment took place under controlled environment (illumination, temperature, *etc*.) in the sensory laboratory of the Department of Food Science and Technology at the University of Natural Resources and Life Sciences Vienna.

Participants were instructed to look at the pictures at the monitor in a relaxed way, with the mouse in their dominant hand and not to change their sitting position during the test. After successful calibration, the test started with an instruction text on the screen explaining the procedure in detail (for a detailed flowchart of the procedure see Figure 2). The participants were told to look at the pictures and choose the food product which appealed most to them out of the choice set, without time limitation. Before the first choice set was presented and between choice sets, a black fixation cross was displayed for 3 seconds in the center of the white screen, to center the gazing point and standardize the starting conditions. Then the first choice set was displayed until the participants indicated their choice by clicking with the left mouse button, the mouse pointer was not visible during the decision-making. On the next screen, the mouse pointer appeared and the participants were instructed to state their choice by clicking on the chosen object. Only the data of participants stating their choice within 2 seconds after they read

the instructions and directly following the mouse pointer to the object they chose (the positon of the objects during stayed the same as on the screen before) without investigating the other alternatives were used for the data analyses. This was necessary to ensure that the participants did not change their decision between decision-making (first click with left mouse button) and choice-stating (clicking on the product). This procedure was explained to the participants in detail before they started the test and a warm up choice set, was used to familiarize the participants with the procedure.

Following six eye-tracking parameters were measured: 1) Time to first fixation (TTFF): time elapsed between the appearance of a picture and the user first fixating his/her gaze within an Area of Interest (AOI), in this case each product was defined as a separate area of interest. 2) First Fixation Duration (FFD): time a user gazes at his/her first fixation point. 3) Fixation duration (FD): length of a fixation (in seconds). Average FD was used for statistical analyses. 4) Fixation count (FC): number of fixations on product. 5) Dwell duration (DD): time elapsed between the user's first fixation on a product and the next fixation outside the product (in seconds). The total dwell duration (sum of all dwell durations on an alternative) was used during a choice task for statistical analyses. 6) Dwell count (DC): number of "visits" to an AOI.

The gazing behavior of the participants was recorded during the whole testing procedure, but only the gazing data during the decision-making process, starting with the presentation of the stimuli and ending when the participant stated that he or she made a decision, was used for the data analyses (stating the choice itself, by clicking on the product picture was not included).

Figure 2 about here

1.3 Statistical analyses

χ^2-square test was used to test differences in choice frequency. To investigate effects of choice and product variant on the measured gazing parameters Repeated Measures Analysis of Variance (RMANOVA) with TTFF, FFD, FD, FC, DD and DC as dependent measures, product

variant as within subject factor and the stated choice as between subject factor was conducted. To analyze the gazing behavior in dependence of choice in detail, stated contrasts were used. Binomial test was used to test the relationship between last fixation and choice. IBM SPSS Statistics 20 (IBM Corporation, Armonk, USA) software was used to analyze the data.

2 Results and Discussion

2.1 Choice frequency

Each product was chosen at least four times, and statistically significant differences in the choice frequency were found for five out of eight product sets (Figure 3). In case of beer and salad these differences are prominent in particular; one product alternative was chosen by less than ten percent of the participants.

Figure 3 about here

The mean decision time was the shortest for the product group soft drink with 4.7 seconds and the longest for instant soup with 6.7 seconds in average. The other six product groups ranged between these two.

2.2 Eye-Tracking Measures

According to the results of the Repeated Measures Analysis of Variance (RMANOVA) (Table 1) the product had a significant effect on the gazing behavior for the product groups of chocolate, salad, soda and instant soup. No significant effect of the product choice was observed over all eight categories. However, highly significant interactions between product and choice were found for all eight product groups, indicating the chosen product was gazed at differently than not chosen ones.

Table 1 about here

Product effects on gazing behavior

Analyzing the significant effects in detail, the univariate tests indicate that the product had a significant effect on TTFF for the beer category, on FD for the chocolate category and on DD for instant soup and salad (Table 2). Furthermore, significant product effects were observed on FC and DC for salad and sausage products. Examining these effects in detail, most *post hoc* tests did not show significant differences.

Table 2 about here

H1: The chosen food product receives more visual attention

Significant interactions between product and choice were observed for several eye-tracking parameters including TTFF, FD, FC, DD and DC (Table 2). The latter three were highly significant for all eight product categories. These results indicate that there are clear differences between the visual attention for a chosen product and the non-chosen alternatives.

H1a: The chosen food product receives more visual attention in form of more fixation counts

Investigating fixation counts for all eight choice sets, in dependence of the stated choice, the chosen product variant received in 31 out of 32 cases more fixations than each of the not chosen alternatives, confirming hypothesis H1a (Table 3). In 17 cases, the within subject contrasts showed that the chosen object received significantly more fixations than the three other alternatives.

H1b: The chosen food product receives more visual attention in form of longer dwell duration

Results for dwell duration are very similar as for fixation counts. Dwell duration was in 31 out of 32 cases longer for the chosen product then for each of the corresponding alternatives, which confirms hypothesis H1b. These differences were significant in 24 cases.

H1c: The chosen food product receives more visual attention in form of more dwell counts

The chosen product received in 30 out of 32 cases more dwell counts than each of the alternatives, confirming hypothesis H1c. In 20 cases the within subject contrasts showed that the chosen object received significantly more dwells than the three other alternatives.

Summarizing H1, the chosen food products received more visual attention in forms of a) fixation counts b) total dwell duration and c) dwell counts. This supports our hypothesis for all three parameters and is in accordance with the findings of ORQUIN and MUELLER LOOSE (2013) and JANTATHAI and co-workers (2013).

Table 3 about here

H2: The first fixated product is more likely to be chosen than its alternatives

Using the Binominal test no indication was found that the product first fixated was chosen more often than the other products, ($p > .05$) across all eight product groups (Figure 4A). Therefore, H2 could not be confirmed with this study and supports the findings of VAN DER LAAN and co-workers (2015).

H3: The last fixation before the decision is on the chosen alternative

The last fixated alternative was chosen between 88 % in case of the bread choice set and 69 % for the salad choice set (Figure 4B). The Binominal test showed that the last fixated alternative was significantly more often chosen then expected by chance, ($p < .001$) for all eight choice sets, therefore supporting hypothesis H3 as well the findings of ORQUIN and MUELLER LOOSE (2013).

Figure 4 about here

H4: The relationship between gazing behavior and choice is consistent for different food product groups

Summarizing the results the RMANOVA and the subsequent tests (Table 2 & 3 and Figure 4) the relationship between choice and gazing behavior are very consistent across the eight choice sets supporting H4.

It must be remarked that the presented study was conducted using exclusively university students aged between 18 and 28 as subjects. Therefore, generalization of the results for the general population is not possible.

3 Conclusions

By examining the gazing behavior during multialternative choice tasks using eye-tracking technology very strong correlations between choice and gazing behavior, in forms of more fixation counts, longer total dwell duration and more dwell counts, on the chosen alternative, were found. These results were consistent across the all eight tested product groups.

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240 **Table 1**

		Apple	Beer	Bread	Chocolate	Instant Soup	Salad	Sausage	Soft Drink
Effect	df	F-value	F-value	F-value	F-value	F-value	F-value	F-value	F-value
Product	(18,38)	.989	1.511	.565	4.561***	2.655**	3.18**	1.356	2.128***
Choice	(18,156)	.983	1.232	.835	.937	.764	1.117	.919	1.069
Product×Choice	(54,120)	3.423***	2.452***	4.345***	2.781***	1.803***	2.333***	2.210***	2.703***

df… degrees of freedom

** indicates significant effect at a significance level of $p < .01$ and *** $p < .001$.

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	Eye-Tracking parameter	df	Apple F-value	Beer F-value	Bread F-value	Chocolate F-value	Instant Soup F-value	Salad F-value	Sausage F-value	Soft Drink F-value
Product	TTFF	(3,165)	2.395	4.162**	.063	1.065	1.266	.806	.246	.367
	FFD	(3,165)	.413	.813	.155	.925	1.059	2.296	.186	1.321
	FD	(3,165)	.326	1.279	.079	3.043*	.605	.223	.895	.964
	FC	(3,165)	.338	.208	1.800	1.820	4.393**	4.353**	2.959*	1.145
	DD	(3,165)	.280	.621	1.032	1.332	4.182**	2.870*	1.958	.526
	DC	(3,165)	2.167	.071	.800	.101	5.721**	4.733**	2.928*	1.914
Product × Choice	TTFF	(9,165)	.862	2.722***	.588	.622	1.145	.497	.68	.419
	FFD	(9,165)	1.189	1.490	.964	1.669	.468	1.303	1.645	.636
	FD	(9,165)	2.872**	.454	4.625***	1.78	.594	.662	1.067	2.596**
	FC	(9,165)	9.364***	6.261***	1.304***	5.891***	6.236***	4.041***	5.157***	2.901**
	DD	(9,165)	13.695***	8.185***	14.85***	6.289***	8.063***	3.803***	5.64***	3.098**
	DC	(9,165)	9.866***	6.001***	11.95***	6.169***	6.572***	4.007***	5.305***	5.113***

df… degrees of freedom

* indicates significant effect at a significance level of $p < .05$, ** $p < .01$ and *** $p < .001$.

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Table 3

Choice		Eye-Tracking Measurement: Dwell Duration [s] P 1	P 2	P 3	P 4	Fixation Count [n] P 1	P 2	P 3	P 4	Dwell Count [n] P 1	P 2	P 3	P 4
Apple	P 1	2.37**	1.21	.97	.86	6.70*	3.90	3.40	3.30	3.10*	2.40	1.90	2.00
	P 2	.81	1.52*	1.04	.95	3.20	5.10*	3.40	3.50	2.00	3.00*	1.60	2.00
	P 3	.68	.75	1.92**	.75	2.36	2.64	5.00*	2.91	1.73	1.82	2.82*	1.64
	P 4	.89	.85	.69	1.88***	3.32	2.96	2.46	5.29***	2.07	2.04	1.64	2.71***
Beer	P 1	1.74*	.89	1.18	.97	5.85	3.40	5.05	3.75	2.70	1.50	2.30	1.75
	P 2	1.38	2.22*	1.19	1.25	5.40	6.80	4.80	4.80	2.60	3.40	2.40	2.40
	P 3	.85	1.01	1.58*	.85	3.18	3.59	5.00*	3.59	1.86	2.00	2.32	1.86
	P 4	.93	1.49	1.07	2.25**	4.08	5.17	4.67	7.50**	2.17	2.17	2.17	3.08**
Bread	P 1	2.28***	.84	1.08	1.20	5.96**	3.00	3.69	3.89	2.89***	1.65	1.77	1.85
	P 2	.57	2.86*	.80	1.13	2.38	9.25*	3.50	3.88	1.25	3.00*	1.63	1.88
	P 3	.67	.82	1.78***	.54	2.56	2.81	5.25***	1.94	1.56	1.56	2.56***	1.38
	P 4	.80	.75	.69	2.00***	2.89	3.11	2.44	6.44***	1.56	1.89	1.44	2.44
Chocolate	P 1	1.54*	.95	1.02	.89	6.467*	4.47	4.13	4.53	2.73**	2.13	1.93	1.67
	P 2	1.08	1.20	.83	.75	4.27	5.07	3.60	3.53	1.80	2.27	1.80	1.67
	P 3	.98	.65	1.93**	1.09	4.05	2.96	6.32*	4.32	1.50	1.36	2.27**	1.55
	P 4	1.72	1.60	1.05	2.77*	5.14	6.29	4.71	1.43*	2.29	2.29	2.29	3.29
Instant -soup	P 1	1.71	1.46	1.08	1.10	6.48	5.89	5.04	4.48	2.48**	1.81	1.56	1.48
	P 2	.83	2.33*	.95	1.16	3.56	8.67	5.00	5.00	1.78	2.44*	1.89	2.00
	P 3	.90	1.41	2.03*	1.35	3.82	5.46	7.64	5.73	1.73	1.82	2.72**	1.91
	P 4	1.15	1.32	1.41	2.45**	4.33	5.58	4.92	9.50*	1.83	1.67	1.58	2.17
Salad	P 1	1.40*	.65	.99	.75	4.83*	2.67	3.33	2.22	2.61*	2.11	2.11	1.67
	P 2	1.04	1.49*	.97	.86	3.69	4.76*	3.48	2.93	2.21	2.93**	2.14	1.66
	P 3	1.39	.75	1.64	.72	5.38	2.88	5.50	2.63	3.25	2.00	3.25	1.75
	P 4	.95	.88	1.67	1.37	3.00	3.50	5.25	4.25	1.75	1.75	2.00	2.00
Sausage	P 1	1.15*	.84	.63	.76	3.87	3.67	2.73	2.93	2.40*	2.07	1.67	1.60
	P 2	1.23	2.16**	1.20	1.13	4.60	7.95**	4.80	4.30	2.75	3.55***	2.30	2.35
	P 3	.81	1.10	1.73*	.78	3.29	4.41	6.29	3.00	2.06	2.12	2.71	1.88
	P 4	.61	.60	.65	.88	2.57	2.57	2.29	3.86	1.71	1.57	1.43	2.00
Soft Drink	P 1	1.40	.48	1.07	.59	4.15	2.35	3.60	2.60	2.50*	1.50	1.95	1.70
	P 2	.73	1.25*	.52	.57	3.18	4.27	2.27	2.27	1.82	2.27*	1.46	1.27
	P 3	.95	.64	1.04	.72	3.33	2.53	3.87	2.27	1.80	1.40	2.27*	1.33
	P 4	.66	.86	.64	1.17	3.15	3.15	2.62	4.08	1.92	1.77	1.77	2.54

[+] Product (P)

* indicates significant differences at a significance level of $p < .05$, ** $p < .01$ and *** $p < .001$.

Table 1: Results of the Repeated Measures ANOVA.

Table 2: Results of the Repeated Measures ANOVA (RMANOVA). Factor choice is not stated due to any significant effects observed in RMANOVA.

Table 3: Gazing behavior in dependence of choice. Fields marked grey indicate the highest value of the corresponding eye-tracking measurement when product (P) 1, 2, 3 or 4 were chosen. Contrast calculation was used to find out whether the chosen product received more visual attention compared to the other product alternatives

Figure 1: The eight presented choice sets from top left to bottom right: Apple, Beer, Bread, Chocolate, Instant Soup, Salad, Sausage, Soft Drink.

Figure 2: Flowchart of the testing procedure on the example of Apple. Eye-tracking retrieved during the decision-making section was used for the statistical analyses; there was no time limitation during decision-making.

Figure 3: Frequency of choice for all eight choice sets with each four alternatives. * indicates significant effect at a significance level of $p < .05$, ** $p < .01$ and *** $p < .001$.

Figure 4: Relationship between A) First Fixation and B) Last Fixation and product choice.

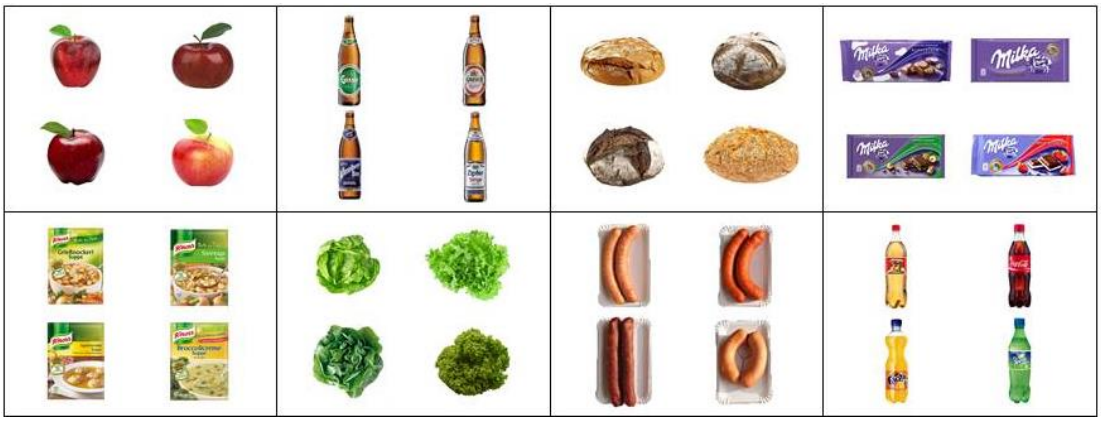


Figure 1

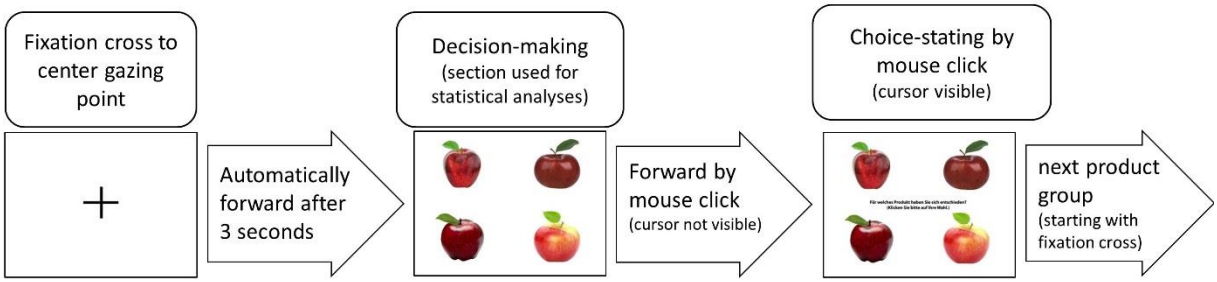


Figure 2

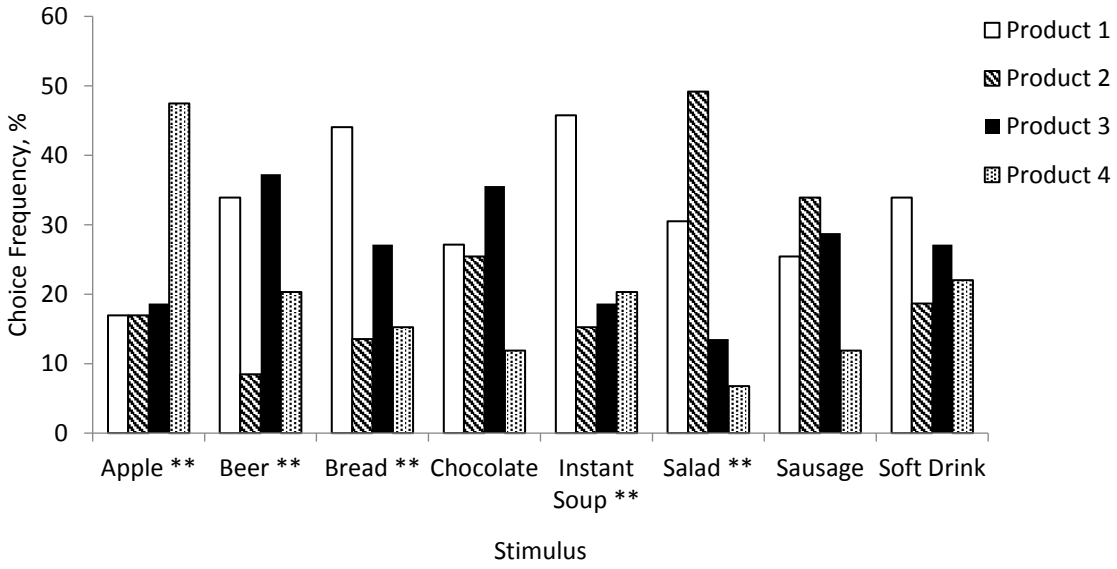
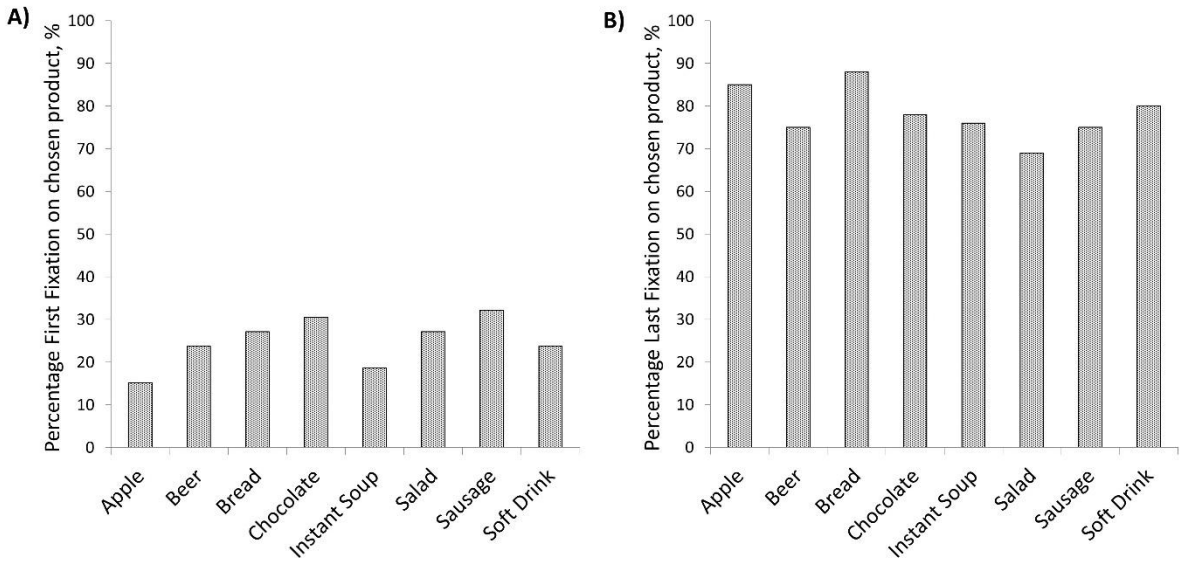


Figure 3



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