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An eye tracking based examination of visual attention during pairwise comparisons of a digital product's package

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Abstract. The paper presents results of the experimental investigation based on the eye tracking data regarding the pairwise comparisons of box package designs. Persons taking part in the study were asked to visually analyze and express their perceived purchase intentions towards various types of product packages. During the whole process subjects' visual activities were registered by an eye tracking system. The research explores two factors, where each is examined on two levels, namely: a box package with and without curved edges, and a package variant with and without a product image. The gathered oculographical data based on fixations were analyzed in defined areas of interests (AOIs). Finally, the obtained subjective subjects' preferences were compared and discussed with the objective eye tracking data.

Keywords: eye tracking · digital product presentation · package design · digital signage · AHP

1 Introduction

Research regarding human visual activity in a marketing context has a long history. Wedel and Pieters (2008) in their article reviewing eye tracking applications in this field refer to experiments conducted as early as in 1924. The development of more and more usable devices in the 90s of the 20th century resulted in a significant increase in the number of this type of studies. Furthermore, there are some methodological reasons that make the eye tracking studies attractive for scientists. In comparison with traditional methods, for instance, it allows for direct registration of quick attentional processes that are very often unconscious to a subject. Additionally, the researchers have a tool to verify existing results and models in a far more objective way than previously.

The research effort of the eye tracking based investigations in marketing has been directed, among other things, to examination of attentional dynamics concerned with printed advertisements, television commercials or web sites. In recent years occulographical studies also concern product packages. Among package design components that influence human being visual attention one usually includes (Piqueras-Fiszman et al. 2013): the package shape and texture, the location of informative items, labels etc. A number of latest studies in this regard deal with nutrition product packages. Graham et al. (2012) in their work presented a review of eye tracking analyses regarding identification and usage of nutrition information. The experiments allowed for creating detailed principles of the nutrition labels design. Some of the recommendations such as the clutter reduction of the label surrounding or the font size optimization were not possible to formulate earlier so precisely.

The application of scan paths tracking enabled the identification of relations between selected package attributes and customers' willingness to pay. Van Loo et al. (2015), for instance, showed that sustainability labels placed on the roasted ground coffee packaging lead to the increase of the acceptable price among people devoting more attention – measured by the dwell time and number of fixations – to these labels. In turn, Piqueras-Fiszman et al. (2013) documented an interesting phenomenon of the influence of ridged surface on extending the observer's penetration area towards edges and a flavor label of the examined jar of jam – and thereby increase willingness to try.

Chowdburry et al. (2012) examined scanpath patterns in mutated brands identification tasks. The exemplary illustrations of fixations and saccades registered during visual inspection of such products placed in shop shelves suggest that people apply the pairwise comparisons strategy in this type of visual search tasks. This mechanism was initially suggested by Van Raaji (1977) who directly observed of subjects' eye movements by means of a one-way mirror and recording camera. The findings of these papers constituted inspiration for the current study. The main goal of the present experiment is to try to identify the impact of specific package features on overt attention (Findlay and Gilchrist, 2003) characteristics during performing pairwise comparisons of various package designs.

2 Method

2.1 Participants

A total of 23 student volunteers took part in the experiment. The age ranged from 19 to 47 years with the average of 22.2 and a standard deviation equaled 5.6. There were six males and 17 females participating in the study.

2.2 Apparatus

Custom made software was employed to present current study experimental stimuli. The same application was used for eliciting subjective weights according to the AHP methodology (Saaty 1977, 1980) based on pairwise comparisons. The gathered data were next exported to a statistical package for analyses. The examination was conducted in similar lighting conditions on a personal computer working under XP Microsoft Operating system and a 19 inches screen with a classic color scheme.

A SMI infrared eye-tracker system was used to track and collect occulographical data while making the comparisons. The system was composed of eye glasses and a laptop computer with a SMI iView ETG 2.2 recording application. The device allowed for recording eye ball movements at 60 Hz sample rate. Gaze analysis software (SMI BeGaze 3.5), was used for exporting raw data that were then analyzed in a statistical application.

2.3 Stimuli, experimental design and dependent variables

The study investigates a subjects' perceived willingness to buy a smartphone based on a digitally presented package. W prepared simple, three dimensional prototypes differed by two independent factors. Each factor was specified on two levels. The shape effect included a box package with or without curved edges, while the second one involved a package variant with or without a product image. A combination of these factors and their levels produced four different experimental conditions which are illustrated in Fig. 1.

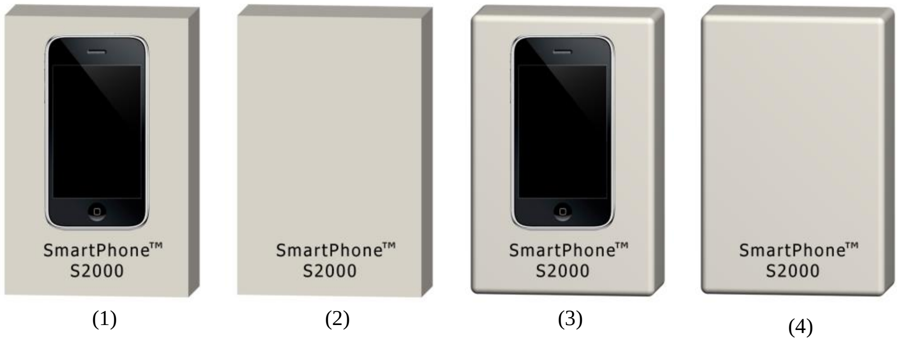

Fig. 1. All four experimental conditions examined in the present study.

A within subjects design was employed, thus each subject compared the set of all package variants. The subjective weights were computed based on these pairwise comparisons, by means of the AHP technique (Saaty, 1977; 1980). Detailed calculation techniques may also be found e.g. in Michalski (2014).

Basic analysis of eye tracking data is usually based on saccades and fixations (Goldberg and Kotval 1999) which are the basic properties of a human visual behavior. A fixation refers to a situation when a person spends more time in a given location while a saccade is just a rapid jump of an eye ball between two fixations. In the presented analyses the fixation was defined according to a dispersion based algorithm with a minimum duration threshold (Salvucci & Goldberg, 2000) when detected gazepoints lasted longer than 80 milliseconds and their dispersion was smaller than 100 pixels (BeGaze Manual, 2015).

Along with subjective preferences, the following objective data regarding participants' visual activity were used as dependent variables: dwell time, fixation durations, fixations count, fixated time, and pupil diameter.

2.4 Experimental procedure

At first, participants were informed about the general objective of the study. After providing some basic data about themselves they put on the eye tracking glasses. Directly before the proper examination, the fast, one point calibration procedure was applied. The subjects' task was to assess which of the two presented smartphone packages would better persuaded them to buy the product. The image pairs were presented at random order by the experimental software. An example of such a comparison with a superimposed area of interests used for eye tracking data analysis is demonstrated in Fig. 2. During the whole process, subjects' visual activities were registered by the eye tracking system.

Fig. 2. An exemplary comparison presented by the experimental software. The superimposed Areas of Interests (numbers are explained in Table 3) were not visible during the examination.

3 Results

3.1 Perceived purchase willingness

Basic statistics. The applied AHP framework allowed for controlling the subjects coherence of responses by computing the so called consistency ratio (CR) for each individual. The obtained values of CRs ranged from 0 to .042 with mean .016 and standard deviation of .0105. The observed values were far lower than the recommended .1 so all subjects' results were included in further analyses. The final hierarchy of examined conditions is presented in Table 1. Bigger mean weights denote higher preferences.

Hierarchy	Condition		Mean weight (SD)	
1.	**3. Rounded**	**Picture**	.3162	(.0508)
2.	**1. Sharp**	**Picture**	.2724	(.0456)
3.	**4. Rounded**	**No Picture**	.2199	(.0391)
4.	**2. Sharp**	**No Picture**	.1915	(.0375)

Table 1. Final hierarchy of investigated conditions based on mean weights of the purchase intentions. Standard deviations in brackets.

The results exhibit clear pattern showing that the inclusion of smartphone picture raises the average purchase intentions. Similarly, application of rounded box packages were more liked than the same variants with sharp edges. The observed pattern can be easily recognized in Fig. 3.

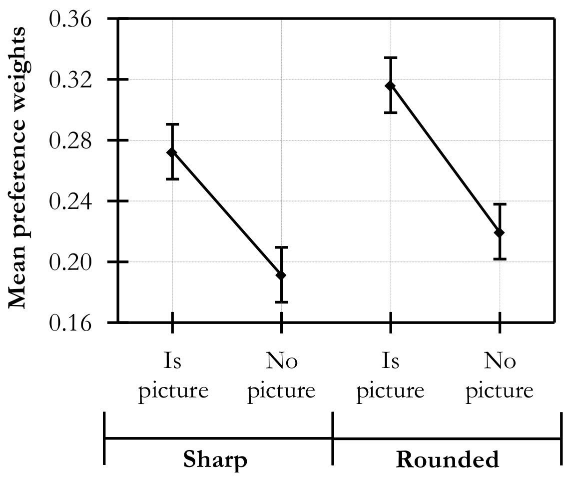

Fig. 3. Mean preference weights for all experimental conditions. Vertical bars denote 0.95 confidence intervals.

A series of LSD Fischer's pairwise comparisons between all experimental conditions revealed that differences between all of them were statistically significant at .05.

Analysis of variance. A classic two way analysis of variance *Package shape* × *Picture presence* was used for formal verification whether the investigated factors and their interaction had a significant impact on mean willingness to buy a product. The computed data are put together in Table 2. The results revealed that both examined effects, differentiate average scores meaningfully: $F_{Shape}(1, 88) = 16$, $p = .00015$ and $F_{Picture\ presence}(1, 88) = 95$, $p < .0001$. The interaction between these factors was irrelevant.

Effect	SS	df	MS	F	p	η²
Package shape	.030	1	.030	16	.00015*	.15
Picture presence	.18	1	.18	95	<.0001*	.52
Package shape×Picture presence	.0014	1	.0014	.71	.40	.0080
Error	.17	88	.0019			

*p < .001; df–degrees of freedom; SS–sum of squares; MS–mean sum of squares; η^2–partial eta-squared

Table 2. Two-way (Shape × Picture presence) analysis of variance results.

Average values of subjective purchase intentions for the significant factors are graphically illustrated in Figs. 4 and 5 and clearly confirm the observation taken in the previous section. Rounded versions of the packages were better perceived than their sharp counter parts and box variants with pictures were better liked than options without them. The partial eta-squared values from Table 2 indicate that the Picture presence effect was decidedly more important than the Package shape factor in forming subjects' opinions.

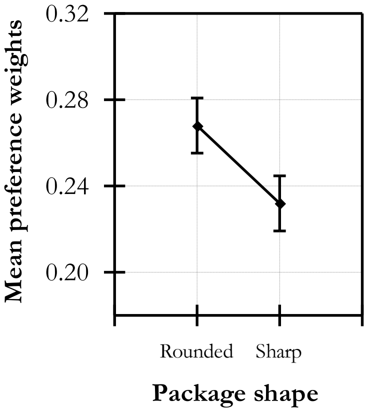

Fig. 4. Mean subjective purchase intentions for the *Package shape* factor. $F(1, 88) = 16$, $p = .00015$. Vertical bars denote .95 confidence intervals.

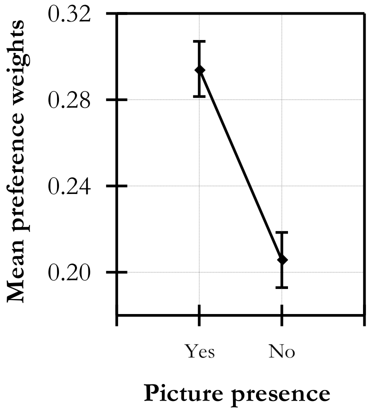

Fig. 5. Mean subjective purchase intentions for the factor. $F(1, 88) = 95$, $p < .0001$. Vertical bars denote .95 confidence intervals.

3.2 Eye tracking data analysis

The obtained occulographical data were analyzed in particular parts of the presented stimuli by specifying the so called Area of Interests (AOI). By means of the SMI BeGaze 3.5 software two groups of AOIs were created. The first one concerned sections demonstrating the product package and included the following items: 1. Box rounded edges (EdgRnd), 2. Box sharp edges (EdgShr), 3. Box content without a picture (ConNoPic), 4. Box content with a picture (ConIsPic), and 5. Box captions (Caps). Additionally, the fourth AOI was divided into two subsections: 4.1. Phone edges (PhoEdg) and 4.2. Phone center (PhoCen). The second group comprised of regions related with the process of making comparisons, that is: 6. Task order (TskOrd), 7. Center area (Center), 8. Rating scale (Scale), 9. Buttons (Btns), and the remaining area where none particular objects were visible 10. White space (WhiSpa). The prepared AOI are schematically demonstrated in Fig. 2.

Basic statistics. Table 3 presents major parameters regarding defined AOIs. The data provide a general overview of subjects' visual activity in specified regions. It may be observed that people spent most of the time both fixated and not looking at the region where the scale was located (AOI 8). The number of fixations and even the average fixation was also the biggest for this AOI. Among the least interesting locations were the place with the task order and the area between the two package images (AOI 6 and 7 respectively). One can also notice that number of fixation was decidedly bigger for conditions with a smartphone picture that without it: 410 versus 217, however the difference in mean fixations for these conditions seems to be negligible: 193 versus 190. A considerable difference between basic temporal parameters was obtained for the areas presenting the center of the smartphone and its edges. Although, both dwell and fixated times were longer for the smartphone's edges, the mean fixation time was longer for the center of the smartphone's picture than for its edges: 203 versus 185.

AOI	**Size** (pixels)	**Coverage** (%)	**Dwell time** (ms)	**Normalized dwell time** (ms/coverage)	**Fixation count**	**Fixation time** (ms)	**Average fixation** (ms)
1. EdgRnd	29 469	4.15	39 102	9 422	191	36 588	192
2. EdgShr	29 469	4.15	39 615	9 546	210	36 770	175
3. ConNoPic	38 628	5.4	44 983	8 330	217	41 921	193
4. ConIsPic	38 628	5.4	85 843	15 897	410	77 927	190
4.1 PhoEdg	16 547	2.3	56 087	24 386	290	53 573	185
4.2 PhoCen	22 079	3.1	29 755	9 598	120	24 354	203
5. Caps	10 034	1.4	76 975	54 982	364	72 666	200
6. TskOrd	46 483	6.5	10 450	1 608	57	9 000	158
7. Center	47 972	6.8	12 795	1 882	70	11 681	167
8. Scale	97 679	14	238 175	17 013	911	203 467	223
9. Btns	51 512	7.2	53 988	7 498	244	49 182	202
10. WhiSpa	310 842	44	125 692	2 857	560	109 907	196

Table 3. Basic statistics of the main eye tracking data for all of the defined AOIs.

Analyses of variance. A formal statistical verification of the influence of various types of AOIs (box captions, box content, box edges), package shapes (rounded, sharp), and the smartphone picture presence (with and without a picture) on essential temporal variables was conducted by means of a series of three-way Anovas. The obtained results for four dependent variables are given in Table 4. These data reveal statistically significant ($\alpha = .05$) impact of the *AOI type* and *Picture presence* effects on *Dwell* and *Fixated time* as well as on the *Fixation count*. The mean *Fixation duration* was meaningfully ($\alpha = .1$) differentiated by the *AOI type* × *Package shape* interaction. In all other cases the differences were statistically irrelevant. The statistically important relationships are graphically illustrated in Figs. 6-10, where vertical bars denote .95 confidence intervals.

Effect	**Fixation duration**		**Dwell time**		**Fixation count**		**Fixated time**	
	F	**p**	**F**	**p**	**F**	**p**	**F**	**p**
AOI (A)	1.7	.18	3.4	.034**	3.9	.020**	3.1	.048**
PicPres (P)	.02	.89	4.7	.031**	6.0	.015**	4.6	.033**
PackShape (S)	.00	1.0	.48	.49	.61	.43	.77	.38
A×P	.51	.60	1.3	.26	1.5	.22	1.1	.34
A×S	2.8	.061*	1.1	.34	1.3	.29	1.0	.36
P×S	.44	.51	.76	.38	.24	.63	.86	.35
A×P×S	1.2	.29	1.6	.21	1.2	.29	1.7	.18

*p < .1; **p < .05; A - AOI Type, P - Picture presence, S - Picture shape,

Table 4. A series of three-way (*AOI type* × *Picture presence* × *Package shape*) Anova results.

A series of LSD Fischer pairwise comparisons for the significant interaction of *AOI type* × *Package shape* on mean fixation durations (Fig. 6) showed that for rounded package versions there was only one significant difference between *Captions* and *Content* ($p = .095$); for sharp conditions the difference between *Captions-Edges* as well as *Content-Edges* was significant ($p = .045$ and $p = .0021$ respectively); meaningful discrepancy between sharp and rounded conditions were noticed only for the *Content* ($p = .012$).

The LSD Fischer post-hoc analysis of the *AOI type* effect (Fig. 7) revealed significant differences between mean dwell times for *Captions-Content* ($p = .044$) and *Content-Edges* ($p = .0077$). Similar pattern was observed for mean fixated times with $p = .073$ and $p = .011$ respectively.

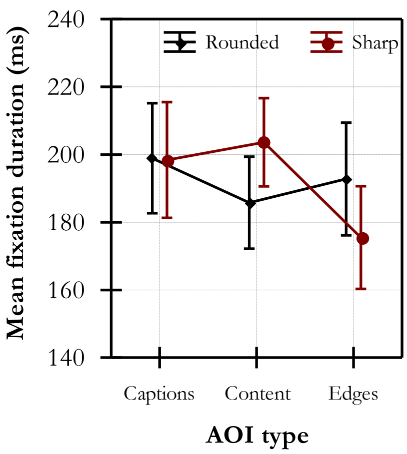

Fig. 6. Mean fixation durations for the *AOI type* × *Package shape* effect. $F(2, 1266) = 2.8$, $p = .061$

An analogical analysis was conducted for the AOI type effect on mean fixation time (Fig. 9). In this case, the LSD tests showed significant differences between Captions -Content (p = .0103) and Content-Edges (p = .0069). The difference between Captions-Edges was statistically irrelevant.

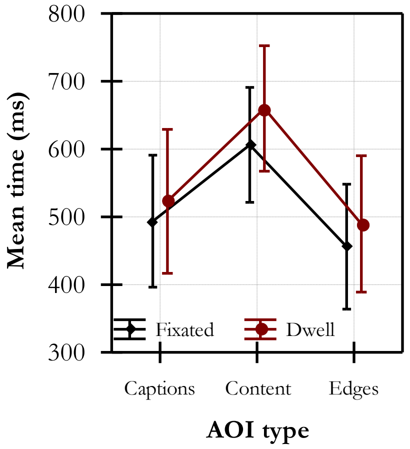

Fig. 7. Mean dwell and fixated times for the *AOI type* factor. $F_{Fixated}(2, 491) = 3.1$, $p_{Fixated} = .048$, $F_{Dwell}(2, 491) = 3.4$, $p_{Dwell} = .034$.

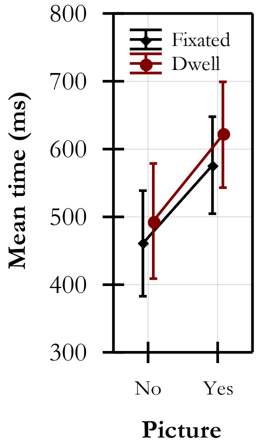

Fig. 8. Mean dwell and fixated times for the *Picture presence* factor. $F_{Fixated}(1, 491) = 4.6$, $p_{Fixated} < .033$, $F_{Dwell}(1, 491) = 4.7$, $p_{Dwell} < .031$.

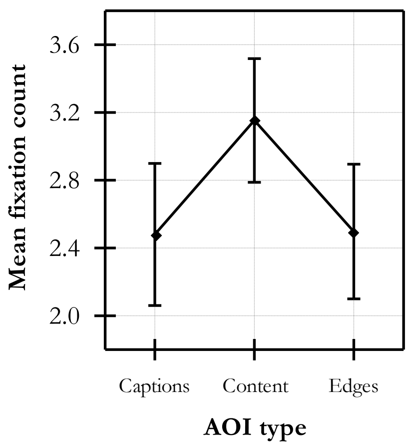

Fig. 9. Mean fixation counts for the *AOI type* factor. $F(2, 491) = 3.9$, $p = .020$.

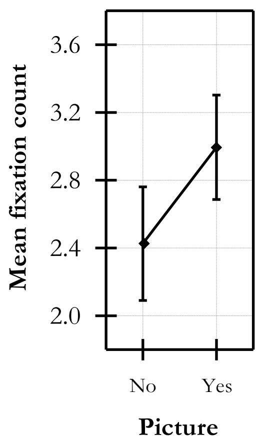

Fig. 10. Mean fixation counts for the *Picture presence* factor. $F(1, 491) = 6.0$, $p < .015$.

An additional Anova was applied to check if there was any impact of *AOI type*, *Picture presence*, and *Package shape* on the pupil diameter. The biggest differences in mean values were observed for the *Picture presence* effect: for conditions with smartphone pictures the mean pupil diameter equaled 6.7 mm (Standard Mean Error = .66) versus 5.2 mm (SME = .78) for cases without that image. Though the analyses generally showed no statistical significance for any of the examined factors, the probability for the *Picture presence* effect was on the verge and amounted to .136.

4 Discussion and conclusions

The presented in this paper experiments were focused on examining the influence of package simple attributes on the perceived willingness to buy and, on the other hand shaping the visual attention process in pairwise comparisons. The study revealed the importance of graphical product presentation the on the package box as well as the package shape in determining the purchase behavior of a potential customer identified by means of AHP based pairwise comparisons.

Both the product image presence and rounded edges of the package cuboid decidedly raise purchase intentions. These outcomes correspond with previous research regarding the role of graphical information in cognitive processing (e.g. Underwood et al., 2001 and 2002; Deliza et al., 2003) and with the bigger preference of mild and soft shapes over the edgy ones which is documented for instance in the works of Bar and Neta (2006; 2007), or Suzianti et al. (2015). The application of the eye tracking technique allowed for precise identification of the basic visual analysis parameters' nature and assessment of their influence on attentional processes during packages' comparisons.

The observation of the central area of the presented stimuli prevails in comparisons' strategies used by potential customers. The number of fixations and the fixated time observed in the *Content* AOI are markedly bigger than in other examined areas (Figs. 7 and 9). Interestingly, the role of the box captions and edges seems to be similar. Both factors have a significant impact on the package comparison process.

The major indicators that differentiate the consumers' visual activity, that is, the fixation count, dwell and fixated time in individual AOIs are bigger for conditions with a smartphone picture in comparison with cases where the image was not present (Figs. 7-10). Moreover, consumers' mean fixation duration in rounded packages is longer for *Edges* and shorter for the *Content* as compared with sharp edges package variants (Fig. 6). This finding is consistent with the results obtained by Piqueras-Fiszman et al. (2013) that suggest that the visual penetration field extends when the package box edge is atypical.

Another interesting result obtained in the present study is concerned with the increase of the eye pupil diameter (at the edge of statistical significance) for conditions including the product picture. Since this parameter is considered to be an indicator of emotions, is seems to be interesting to investigate in future studies the influence of graphical proposals having various features on the customer emotional level, for instance, by means of systems capable of identifying emotions directly from the face picture or video.

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