EYE-TRACKING ANALYSIS OF LEAFY VEGETABLES

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ABSTRACT

There is a great supply of leafy vegetables on the market; hence capturing consumer's attention (and decision) is critically important. Several scientific publications deal with consumer choices and the newest technology to capture consumer attention is eye-tracking. Eye-trackers are commonly used in Western Europe and Asia also, where it is an important and widely-used tool during product developments and the creation of marketing strategies. In Hungary, there are only a few publications about eye-tracking applications in vegetable growing and food industry. In our research, photographs about sorrel, lamb lettuce, spinach, leaf lettuce and dandelion leafs were analysed by eye-tracking technology and the eye movements of the participants during their decision making process of leafy vegetables were captured and evaluated. The eye-tracking analyses were carried out in the Sensory Laboratory of the Faculty of Food Sciences of Szent István University, using a Tobii X2-60 eye-tracker and Tobii Studio (version 3.0.5, Tobii Technology AB, Sweden) software. We aimed to answer the following research questions: Are there any connections between the eye movements of participants and their decisions? What amount of visual attention can be registered during the decision making process? Furthermore, the following metrics were measured and evaluated: fixation durations on the leafy vegetables, number of returns to products, pathways of visual attention, time until the final decision making and motivation of their final decisions. Measurement of the subconscious consumer decision making processes is way easier using eye-trackers compared to the traditional questionnaire-based methods, because it is hard or impossible to control our eye movements. Eye-tracking can be used successfully for understanding the expectations and decisions of the consumers.

Keywords: eye-tracking, leafy vegetables, value-based segmentation; eye movements

INTRODUCTION

Acceptance of minimally processed vegetables has been increased in the last few years (ZHOU ET AL., 2004). Wide range of consumers are looking for that products, primarily those who have family with young children and higher education (RAGAERT ET AL., 2004). Psychologic factors also play role in the gazing behaviour not just gender or socio-demographic factors (ARES ET AL., 2014). To understand consumer's gazing behaviour, itis also valuable to analyse the consumer's personal values. For identification of people's behaviour and motives, marketers typically use the so-called value-based segmentation food quality.

Visual attention plays an important role in food choices (GERE ET AL., 2016), because the first impression about the food and their quality takes through visual appearance, which very often is the only attribute that could help in the decision making during the purchase (CARDELLO, 1998; KEAST, 2010). Attributes related to appearance are important for consumers but these are the most susceptible to objective measures (TZIA ET AL., 2016). Eye-tracking is widely used for capturing the eye movements of participants while they are completing different tasks (*e.g.:* choice tasks, free viewing tasks, *etc.*). Several eye-tracking parameters could be measured that can be used to characterize the gazing pattern of the individuals (HOLMQVIST ET AL., 2011).

MATERIAL AND METHOD

This study was a slice of a bigger experiment work, and six alternatives were presented to the participants. Eye-tracking tests were performed in the Sensory Laboratory of the Faculty of Food Science of Szent István University, based on previous eye-tracking studies (GERE, 2016). For the recording and processing of the eye movement data of participants, a Tobii X2-60 static eye-tracker and the Tobii Studio (version 3.0.5, Tobii Technology AB, Sweden) data processing software were used. Images ensured the visual stimuli on a monitor with a 1280x1024 pixel resolution. Participants of the eye-tracking study were recruited from the Buda Campus of Szent István University. Participants were seated in front of a monitor connected to the eye-tracker, meanwhile their eyes were 60 to 65 cm from the monitor. They were asked to place their dominant hand on the mouse and not to move their heads and their positions. Calibrations were carried out before each test, then after the successful calibration, a text containing instructions related to the test appeared on the monitor, in which the process of the test was described in detail. Between the images, there was a black "+" sign, the so-called fixation cross, on the centre of the monitor. The purpose of the fixation cross was to standardize the starting point of attention. This was showed for 3 sec and followed by selection tasks. After reaching the decision, the participant clicked on the left mouse button to bring up the previously invisible mouse pointer on the display, and then they could click on the selected product. 163 people participated in the study and data recording was successful for everyone, but only 140 results were perfectly fitted for the picture that contains six component, these were included in the data analysis.

During the evaluation of the eye-tracking measurement results, work was based on the following definitions (GERE ET AL., 2016): 1. Fixation duration: the average length of fixations on a given area of interest (AoI). 2. Fixation counts: the number of fixations for a specific product that shows how many times the given product was viewed by the participant. 3. Dwell duration: the average length of glimpses at different product images during gaze wandering between two fixations, when no information is absorbed. 4. Dwell count: the total number of visits for a given area of interest (AoI).

Before the test, participants were asked to rate importance of the values listed in the first column of *Table 1*. The labels of the applied 5-point scale were the following: not important at all, less important, moderately important, important, really important.

In this study cluster analysis was used for characterisation and margin of homogenous clusters, that method makes relative homogenous clusters (MALHOTRA, 2005). One advantage is for cluster analysis is that the thinking of the researcher could not affects the segmentation, because method uses distance matrix between data points. During the cluster analysis, hierarchical analysis was done using Euclidean distance and Ward's agglomeration method. Due to the hierarchical nature of the method, the cases were agglomerated step-by-step. The benefit of hierarchical methods is that they try to make almost equal sized clusters and a dendrogram helps to visualize the agglomeration schedule and the structure of the created clusters. XL-Stat software (Addinsoft, 28 West 27th Street, Suite 503, New York, NY 10001, USA) was used for the analyses.

RESULTS

Figure 1 shows a heat map of the fixation durations (from green to red colour means the duration of fixation and red corresponds to the most watched product) of all participants. It shows that leaf lettuce received the most visual attention, after that come rocket salad, and

sorrel. The green spot on the centre of the picture, refers to the previously watched „+"
sign.

**Figure 1. Heat map of the photographs about sorrel, rocket salad, lamb lettuce,
spinach, leaf lettuce and dandelion leaves**

Based on the value structure results of homogenous groups (clusters), were classified by:
  – characterisation of clusters based on their values,
  – characterisation of clusters based on eye movement parameters,
  – characterisation of clusters based on duration of decision making.

Based on the structures of the values, results with one exception (enjoyable life), every
attribute based on eye movement parameters showed significant differences (α=0.05)
according to the applied Kruskal-Wallis test. Based on the results, participants were sorted
into 4 different clusters based on their values (Ward's method, Euclidean distance). Each
cluster was characterised by their mean, dispersion and Dunn's pairwise comparison with
Bonferroni correction, which gives letter markings for homogenous and heterogeneous
groups. That gives an opportunity to analyse clusters about significant differences between
parameters of each cluster. On the top of *Table 1* the values of attributes are showed,
meanwhile below those values are showed parameters about eye movements.
In the **first cluster** the 'conservative self-realized' individuals are located, because they
live a family centred life with conservative custom values, meanwhile true friendship, self-
realization, personal and financial security and education plays also important roles in their
lifestyle. The least important attribute for them is alternative/not traditional living style.
They were the most precious, because the counts of fixations and dwells, and duration of
fixations and dwells were also the highest and the longest during the tests.
Members of **second cluster** are the 'life enjoyed independents', who prefer the following
values the most: true friendship, personal and financial security, enjoyable life, personal
freedom/ independence, although value of traditions was the least important for them. The
eye movement parameters showed, that they fixated shorter and more often on the pictures.
In the **third cluster** we identified the 'financial-social-educated' participants. Most
important values were for them: personal and financial security, true friendship and
education. Interesting that every attributes got higher importance than 'moderately
important' value. Eye movement parameters showed that dwell counts were moderated

compared to other clusters, therefore fixation count and fixation and dwell durations were really low and short such as in case of the fourth cluster.

The fourth cluster contained 'immediate environment centred indifferentists' who actually just interested in family life, true friendship and enjoyable life and other attributes are moderately important for them. Their eye movement parameters tell that they needed the shortest and lowest fixations and dwells (*Table 1*). Based on these, they watched the pictures sloppily.

Table 1. Characterization of clusters by values (the first five values of each cluster are highlighted (darkest is the most important)

Attributes	Cluster1	Cluster2	Cluster3	Cluster4	Kruskal -Wallis
True friendship	4.77±0.42b	4.78±0.52b	4.80±0.40b	4.18±0.65a	**0.0003**
Family life	4.70±0.53b	4.36±0.62a	4.69±0.61b	4.56±0.51ab	**0.0136**
Personal and financial security	4.40±0.62b	4.51±0.55b	4.80±0.40c	3.68±0.94a	**< 0.0001**
Enjoyable life	4.29±0.73ab	4.39±0.62ab	4.50±0.64b	4.06±0.68a	0.1969
Self–realization	4.66±0.57c	4.34±0.61b	4.57±0.64bc	3.62±0.61a	**< 0.0001**
Social origin	4.45±0.62bc	4.12±0.84ab	4.65±0.56c	3.75±1.23a	**0.0059**
Personal freedom/ independence	3.98±0.81a	4.39±0.58b	4.69±0.54b	3.50±1.09a	**< 0.0001**
Education	4.12±0.73b	4.29±0.71b	4.73±0.45c	3.31±0.70a	**< 0.0001**
Comfortable life	3.61±0.70a	4.21±0.65b	4.42±0.70b	3.56±1.03a	**< 0.0001**
Having a lot of free time	3.43±0.68a	4.07±0.81bc	4.30±0.73c	3.81±0.75b	**< 0.0001**
Health consciousness	4.01±0.61b	3.87±0.67b	4.46±0.58c	3.25±0.57a	**< 0.0001**
Good appearance	3.75±0.73b	3.92±0.68b	4.38±0.63c	3.25±0.77a	**< 0.0001**
Economical living	3.31±0.80a	3.75±0.88b	4.26±0.72c	3.37±1.08ab	**0.0001**
Environment and energy conscious life	3.77±0.65b	3.70±0.87b	4.38±0.57c	2.81±0.65a	**< 0.0001**
High living standard	3.40±0.77b	3.92±0.84c	4.15±0.78c	2.75±0.68a	**< 0.0001**
Caring about culture and arts	3.77±0.73b	3.02±0.79a	4.38±0.63c	2.93±0.68a	**< 0.0001**
Social recognition	3.49±0.86b	3.17±0.86ab	4.19±0.84c	2.56±1.03a	**< 0.0001**
Working for the community	3.56±0.65b	3.14±0.85a	3.92±0.74b	2.75±0.85a	**< 0.0001**
Traditions	3.38±0.79b	2.36±0.62a	4.11±0.90c	3.25±0.68b	**< 0.0001**
Alternative/not traditional living style	3.03±1.08b	2.51±1.02a	3.15±1.28b	2.18±0.83a	**0.0028**
Fixation duration	5.37±2.30b	4.40±2.05a	3.74±1.52a	3.54±1.71a	**0,002**
Dwell duration	6.18±3.22b	5.08±2.43ab	4.42±2.64a	3.87±1.46a	**0,0112**
Fixation count	21.85±4.15b	21.24±3.80b	15.11±2.95a	17.26±3.46a	**< 0.0001**
Dwell count	14.73±3.81c	13.53±4.13bc	12.53±2.84ab	11.06±2.67a	**0,0027**

Decision times of the clusters created based on the values were compared by Survival Analysis. The curves' show similar characteristics. First cluster 'conservative self-realized' needed the longest time to make the final decision, that cluster was significantly different ($\alpha=0.05$) from the others.

Participants of third cluster, 'financial-social-educated' and the forth cluster 'immediate environment centred indifferentist' were the fastest decision makers. These two clusters were not significantly different.

Members of the second cluster, ('life enjoyed independents') made their decisions significantly faster compared to participants from the first cluster ('conservative self-realized'); meanwhile they were slower than people in the fourth cluster ('immediate environment centred indifferentist') (*Table 2, Figure 2*).

TABLE 2. Cluster value segmentation (Test statistic showed in the upper-right half-matrix, p-values showed in the lower-left half-matrix). Significant differences are marked with bold.

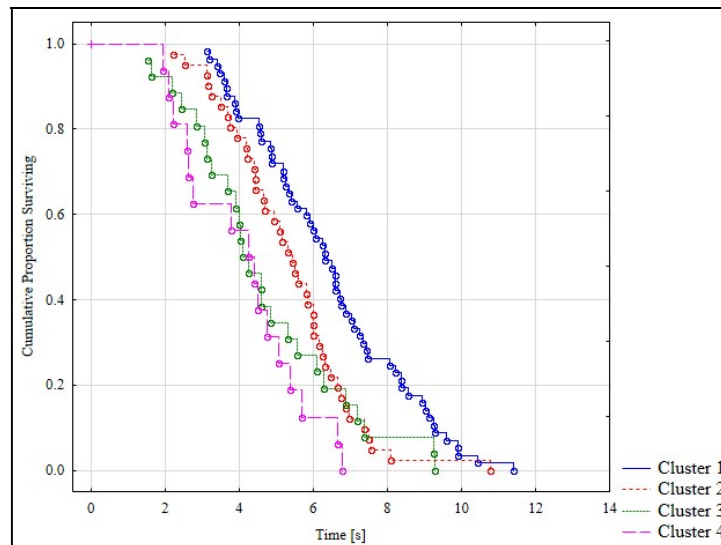|	Cluster1	Cluster2	Cluster3	Cluster4
Cluster1	–	**2.459524**	**3.313691**	**3.727084**
Cluster2	**0.01391**	–	1.756353	**2.370899**
Cluster3	**0.00092**	0.07903	–	0.660465
Cluster4	**0.00019**	**0.01774**	0.50896	–

Figure 2. The obtained Kaplan-Meier surviving plot is generated by plotting the time on the *x*-axis and the proportion of those participants who made their decisions on the *y*-axis

CONCLUSIONS

In this study, leafy vegetables were evaluated which are used as component in salad mixes very often. Participants answered questions which were used to conduct value-based segmentation. The novelty of the experiment was that values and eye movement parameters were evaluated using the combination of different statistical methods (cluster analysis, survival analysis, Kruskal-Wallis and Dunn's pairwise comparison).

Decision times of the clusters created based on the values were used together with eye movement parameters for classification (based on their values, eye movement parameters,

duration of decision making). Values describing the clusters were in accordance with eye movement parameters and with the time needed to make the final decison. Results are useful for package optimisation and selection of mixes contains for target groups (clusters) specially.

ACKNOWLEDGEMENTS

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