Identifying Goal-oriented and Explorative Information Search Patterns

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I. Introduction

One of the latest trends of ubiquitous Information Systems is the use of smartglasses, such as Google Glass or Epson Moverio BT-200 that are connected to the Internet and are augmenting reality with a head-up display. In order to develop recommendation agents (RAs) for the use at the point of sale, researchers have proposed to integrate a portable eye tracking system into such smartglasses (Pfeiffer et al. 2013). This would allow providing the customer with relevant product information and alternative products by making use of the customer's information acquisition processes recorded during the purchase decision.

To make a meaningful recommendation to the customer at the point of sale at the right moment, the RA must be able to detect the decision situation the customer is in which is crucial to determine the required information (Huschens et al. 2014, Moe 2003). As a first step towards building an RA, this paper investigates differences in information search patterns between goal-directed and exploratory purchase situations in which an immediate purchase is intended (Moe 2003, Janiszewski 1998). In goal-directed situations customers will be in need of more goal-related information, like product alternatives that best fit to their individual preferences. In order to find a product which fits their specific needs customers will have to search for detailed product attribute information. For example, they might search for a muesli which includes almonds and chocolate but is of low calories. In an explorative situation, however, customers should be primarily focused on scanning and gathering information about the products available. Based on previous findings, we hypothesize that customers will be less interested in specific information about product attributes, e.g. details concerning the ingredients, but search more for brand- or price-related information.

The work presented here is part of a larger project where we intend to build an RA into smartglasses with eye-tracking capability that can automatically detect the kind of decision situation the customer is in and provide recommendations accordingly. This paper provides first results how eye tracking information can be used to identify goal-oriented and explorative information search patterns. In a first step, we analyse which characteristics of the gaze behaviour can potentially be used to differentiate between the two situations. In a second step, we then use a simple logistic regression analysis to predict whether respondents were in a goal-oriented or explorative condition.

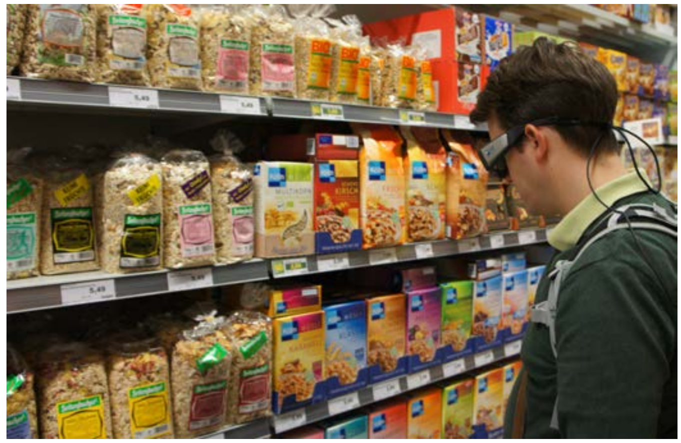

Figure 1. Mobile recommender agents in smartglasses could provide support in decisions at the point-of-sale.

II. Literature Review

Marketing researchers have been especially interested in investigating the in-store and out-of-store factors which influence visual attention and choice. In-store factors are, for example, the number and position of shelf-facings. Important out-of-store factors are past brand usage, the brand's market share as well as demographic criteria and shopping goals. Chandon et al. (2009) examine the interplay between in-store and out-of-store factors on consumers' attention and evaluation processes. They investigated the respective effects for established and new brands which were presented in supermarket shelves. These shelves, however, were simply displayed on a computer screen and stationary (remote) eye tracking equipment was used to record consumers' attention. This setup makes the recorded attentional processes less realistic compared to tracking respondents eye movements at the point-of-sale, as depicted in Figure 1.

Gidlöf et al. (2013) were among the first who investigated the attentional processes of consumers in a more natural decision environment. These researchers were particularly interested in understanding the different stages of the decision process and comparing these stages with previous studies which have used remote eye tracking equipment. They argue that the eye movements are strongly affected by the structure of the task environment which makes it relevant to study search processes in more natural decision situations. Moreover, one main finding of this study is that decision-making tasks were substantial different from search tasks, for example with respect to the number of re-dwells in the second stage of the decision process. Gidlöf et al. (2013) conclude that the "most characteristic feature of decision making is in the use of re-fixations and re-dwells" (p.11).

Janiszewski (1998) argues that contrasting goal-directed and exploratory visual search is of major interest when trying to understand the influence of display characteristics on attention. In line with the goal of getting a better understanding how goal-oriented and explorative information search are different, we suggest to use eye tracking for closely monitoring consumers' attentional processes at the point-of-sale because distinguishing between goal-directed and exploratory behaviour helps to identify the customers' motivation and information needs (Huschens et al. 2014, Moe 2003).

III. Experimental Setup

In an experiment we gave respondents the task of either exploring the product alternatives in the shelf or searching a product that matched to pre-specified product characteristics. The study was conducted in a real world setting, i.e. in a medium-sized supermarket, using mobile eye-tracking equipment. Twenty shoppers were recruited directly after entering the store and they received 10€ as incentive for participation. The mean age in the sample was 31.3 (standard deviation (std.) = 13.27, maximum 53 years) and 70% were female.

Every respondent had to search information for four different product categories. We chose muesli, cereals, marmalade and tea as product categories. The number of products available for each category was 116, 76, 202, and 190, respectively. For each product category the participant was either assigned to a goal-oriented task (GT) or an exploratory task (ET), yielding a group size of ten respondents for each of the four decisions tasks, and two GT and two ET per respondent. In each group, respondents were first read out the task description and then the experimenter ensured that participants had understood the task. In the GT task and the muesli condition, participants were told to select a muesli for a friend who would come for a visit. In that scenario, the friend likes to have a muesli which (1) contains chocolate, (2) contains almond, (3) is as low in calories as possible. In the GT for cereals, the required criteria were (1) contains cinnamon, (2) package smaller than 400 grams, (3) is low in calories. In the marmalade GT, participants were told to look for a marmalade that (1) contains orange, (2) contains at least one additional other flavor and (3) is low in price/kg. In the tea group, the requirements were: (1) is organic, (2) contains peppermint, (3) low price per 100 grams. In each category the number of products fulfilling the first two criteria was eight, two, six, and two respectively. There was exactly one optimal product per category that fulfilled all three criteria. In the ET, participants were asked to gain a fairly good overview about the muesli (cereal, marmalade or tea) assortment and to determine criteria which are important for them when buying the product. Afterwards, they had to choose one product they would potentially buy themselves.

During the tasks, participants wore the SMI Eye Tracking Glasses. 80% of the participants regarded the equipment as not distracting, while 20% regarded it as partially distracting and none as distracting.

IV. Results

Figure 2. Scanpath patterns differ significantly during exploratory (dark grey, participant 04) and goal-oriented (light gray, participant 07) Information Search.

Table 1 shows different measurements describing the gaze behaviour in the two different purchase situations. For example, in 4.29% of the time that the GTs took, participants looked at *price* tags, while in the ETs that percentage almost doubled to 8.12%. *Details* describes the proportion of time respondents looked at detailed information like the ingredients and any other texts that were provided on the packages (excluding pure brand information). In the GT respondents on average fixated 144 products (*fixations*), including refixations on the same product (see Figure 2 for an example). Overall, the number of *refixations* (78 on average) in the GT is much higher than in the ET. *Distance* measures the average distance between two fixations on different products in cm. We can see that the distance is only slightly lower for the GT (43.12cm vs. 44.97cm). Overall participants in the GT spend more *time per product*, which sums up the amount of time that participants looked at each product (including refixations).

Table 1. Results with std. in parentheses

	Goal-oriented	Explorative
Price	4.29% (4.23)	8.12% (7.26)
Details	29.78% (17.65)	8.36% (13.16)
Fixations	144 (129)	97 (64)
Refixations	78 (97)	40 (38)
Distance	43.12cm (19.58)	44.97cm (14.39)
Time per product	1.75 sec (0.93)	0.82 sec (0.40)

We conducted a principal component analysis (PCA) of the eye tracking variables depicted in Table 1 with orthogonal rotation (varimax rotation). Because the Kaiser-Meyer Olkin criterion (KMO) was not met when first including all 6 variables, we excluded *Distance* (based on the measure of sampling adequacy (MSA)) and ran the PCA with the remaining 5 items. The KMO verified the sampling adequacy for the analysis, KMO=0.53. The MSA value was above the acceptable threshold value of 0.5 for all variables included. Moreover, Bartlett's test of sphericity is significant ($\chi^2(10)=267.79$, $p<0.01$) and therefore recommends that the dataset is suitable for factor analysis. We extracted factors with an Eigenvalue larger than 1. Together the two extracted factors explain 78.35% of the total variance.

Fixations and *Refixations* have high positive factor loadings on the first extracted factor (see Table 2). This factor thus represents the general attentional effort of respondents in a task. *Details* and *Time per product* have positive factor loadings on the second factor and *Price* has a negative factor loading. We interpret the second factor as how intensively respondents study the details of the product. If respondents looked more at price information, they also looked less at details which is the reason for the negative factor loading of *Price*.

Table 2. Rotated component matrix

	Factor 1	Factor 2
Price	0.004	-0.595
Details	-0.027	0.900
Fixations	0.986	0.043
Refixations	0.987	0.098
Time per product	0.401	0.795

Subsequently, we used a logistic regression model with standardized *Refixations* and *Details* as explanatory variables because they load highest on the two factors that we identified. With this model, we predict whether the respondent is in a goal-oriented situation (0) or an exploratory situation (1). The results are shown in Table 3 for 68 observations. 12 observations are missing because of technical problems with the USB-port during gaze recording. The results show that the more details are observed by the respondents the lower the likelihood that this respondent is an exploratory situation. The coefficient for Refixations is negative as well but with p=0.12 not significant. A random-effect model that would take into account that we have four observations per participant did not improve the model.

We used 10-fold cross-validation (Kohavi 1995) to estimate the accuracy of the prediction model. Cross-validation randomly divides the data set into equal-sized sub-sets called folds and repeatedly uses them for performance testing. Thus in our case we ten times predict seven out of the cases with an estimation based on the remaining cases. We achieve an average accuracy over the ten folds of 75.24% with a std. of 9.13%. Thus, we are able to differentiate between the two purchase situations in about ¾ of cases which is much higher than pure guessing.

Table 3. Logistic Regression Estimation Results. $^{**}p<0.01$

	Model
Refixations	-0.63 (0.41)
Details	-1.47 (0.36)**
Log likelihood	-32.57
N	68
McFadden R^2	0.31

V. Conclusion

One of the key challenges for developing RAs for use at the point-of-sale is determining customer's intentions. First results show that the attentional effort (the number of fixations and refixations) but even more the level of processing detailed information could be used as indicators of explorative or goal-directed search. Future research should investigate other eye tracking measures in detail to understand which measures are best suited for this purpose. A major challenge lies in tracking and analyzing these eye tracking measures while respondents are processing the information (on-the-fly) in order to be able to give recommendations based on consumers' individual information needs.

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