Designing product listing pages—Effects on sales and users’ cognitive workload

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Abstract

Product listing pages, where information on multiple products are displayed, represent a vital point of an E-commerce website on which consumer decisions are made. Prior research has shown that the design of product listing pages has an impact on users’ performance and their recall of brand names. The aim of this study was to examine effects of presentation on cognitive load and consumer decisions. An online study was conducted comparing presentation type (matrix versus list presentation). List presentation was associated with lower cognitive load and more economic product selections. Eye-tracking data from an additional laboratory experiment suggest that list presentation triggers comparison processes which could account for the differences found.

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1. Introduction

Within the past few years, the Internet has shifted from a supplementary contact point and information medium to an important sales channel for many traditional companies. Within the growing Internet market customers are courted by new competitors, thus improving the usability of an E-commerce website is crucial in order to improve customer satisfaction, boost sales and enlarge customer retention. One of the most interesting pages in the product search process is the product listing page. It usually contains a list of products giving information about the products’ main features, e.g. brand name, price, availability and images. It is the page on which users compare different alternative products and make choices about which products to have a closer look at or to put in the basket. The design of product listing pages can have a variety of effects on decision-making and sales. These aspects have been seldom been considered in past research on product listing pages. The current study will compare different designs regarding experienced cognitive load, products that were chosen by the participants, and shopping cart value. Results based on these aspects will be of interest for usability engineers as well as for website owners.

2. Theoretical background

2.1. Existing research on presentation format

Several major factors are relevant for the design and usability of product listing pages, ranging from target group optimized wording to providing sorting and winnowing facilities as suggested by Nielsen et al. (2001). In this section we will only focus on the product listing presentation format.

Search results or product listings on category pages are displayed nowadays mainly using a list or a matrix presentation format. The list format consists of a table with one product per row (see Fig. 1). Columns may serve as separators for different pieces of information such as the thumbnail image, name, additional information, price, material, or stock availability. In a matrix presentation
format, two or more products can be found in a single row (see Fig. 2). Here, columns serve as separators for different products in a row with all the relevant information pieces in a single table cell. Lists with one item per row and different attributes in the respective columns have three major advantages: (1) They support direct access to desired information due to their two-dimensional nature. (2) Key features can easily be compared because they share the same column. (3) Lists enable features to be sorted thus putting users in control. In turn, these aspects of the list format may become a disadvantage when users are involved in tasks in which comparing products is not
intended. In a study by Hong et al. (2004b) task types and presentation types were varied. They found that the participants performed best in list presentation when they were instructed to buy products of their own choice. However, when instructed to buy specific brands of products, they performed better in the matrix condition. When users visit an online store with the goal of buying a very specific brand, the visual proximity to other brands may interfere with their goals. Users will have to actively suppress nearby information about other products. Matrix presentation supports these tasks by separating different products from each other.

The psychology of reading tabular data or more specifically the effects of list and matrix presentation formats on user performance have rarely been investigated systematically. Most research in this field has concentrated on the question when and how to support the user with graphical representations of tabular data (e.g. Coll et al., 1991; Dickson et al., 1986; Vessey, 2007). Nevertheless, there are a few studies whose results may contribute to the question of using list or tabular product presentations in online stores.

A recent study by Gsponer (2008) on train departure tables showed significant negative effects on users’ performance when departure table rows contained cells with more than one piece of information. Similarly, in the case of matrix product presentations, table cells are often filled with several completely different aspects of a product. This format requires the buyer to find and filter the relevant information while keeping the key information from previous products in working memory. The aspect of cognitive load associated with list and matrix product presentations has been addressed by Hong et al. (2004a). In their study, participants were instructed to browse in several product categories and purchase one brand in each category. They found that lists lower product search time and improve recall of product information such as brand names. They explained these effects with the proximity compatibility principle (PCP) (Barnett and Wickens, 1988): product feature comparison can be supported by reducing the spatial distance of the features in question. This is the case for list presentation, thus reducing eye movements and cognitive load: “Consequently, users can spend more effort on processing the information, resulting in both shorter information search time and better recall of information presented on the screen” (p. 18). This shift of usage of working memory is in line with findings of cognitive load theory (Sweller, 1988; Sweller et al., 1998). Cognitive load theory has been applied in several e-learning and web-related studies in the past, e.g. Brünken et al. (2002, 2003), Dennis et al. (1998), Joseph et al. (2006), Paas et al. (2003), and Schmutz et al. (2009). Sweller et al. (1998) differentiate between three different kinds of cognitive load sharing the same working memory capacity: intrinsic and extraneous cognitive load are especially of interest in the present context and will be explained further. The third, germane cognitive load, mainly applies to learning contexts.

It reflects the effort that contributes to the construction of schemas, automation, and learning. Intrinsic cognitive load is defined as the intrinsic nature of the material or the task. Learning non-interacting elements, for example new foreign vocabulary, is accompanied by a low intrinsic cognitive load because the words are non-interacting and can be learned in isolation. Intrinsic cognitive load cannot be altered as it depends on the material or the task itself. Extraneous cognitive load is affected by the way material is presented and what activities are required to solve a task. In contrast to intrinsic cognitive load, extraneous cognitive load is unnecessary and can be decreased by adequate visual presentation and design of material.

2.2. Aim of this study

The present paper includes two studies, an online and an eye tracking experiment. The aim of the online study was to examine the influence of presentation format, list compared to matrix, on quality of shopping decision and subjective mental workload. With the eye tracking experiment the course of attention across the two presentation modes was investigated.

First study: For the online experiment we used a similar experimental setting as Hong et al. (2004a). In comparison instead of task completion time and product recall, the present study inspected participants’ shopping cart contents in order to gain information on users’ product selection and economic behavior. Additionally, mental workload was measured by means of a post-study questionnaire.

Based on previous research summarized above, we assume that list presentation due to the PCP decreases extraneous cognitive load compared to matrix presentation mode. Ratings of mental workload are expected to be lower in the list condition. Consequently, as more working memory is available, comparison activities should be facilitated and lead to more economic decisions of product choice in the list presentation condition. Hence, the value of the shopping cart content is supposed to be lower in the list presentation mode.

The first study states following hypotheses: H1: Product listings in list presentation mode will cause lower mental workload than product listings with matrix presentation. H2: List presentation mode facilitates comparison resulting in more economic buyer decisions compared to matrix presentation mode in terms of total money spent.

Second study: In an eye tracking experiment, further examinations concerning comparison activities were carried out. The aim was to investigate the course of attention across the two different presentation modes. We examined which differences occurred concerning scan paths between matrix and list presentation modes. Specifically, we hypothesized that due to visual proximity in the list presentation mode, comparison of products is eased and encouraged. H3: The list presentation mode triggers more fixations due to an increased number of comparisons. H4: Longer fixations lengths due to deeper processing of the specific items are expected in the list presentation mode.
3. First study: online experiment

3.1. Method

3.1.1. Study design and participants

We employed a one-way unrelated design to examine the effects of presentation format (matrix vs. list) on user performance and cognitive load. The study was set up as an online experiment. Six Amazon gift vouchers were raffled among all participants. A total of 248 participants were recruited by means of online study portals, blackboards and E-mail newsletters. Data from 49 participants were incomplete due to motivational or technical drop-out and were excluded. For the remaining 199 participants, the average age was 27 years (SD = 8.6) ranging from 16 to 62. Sixty-eight percent were female, 31% male. Ninety-six percent of all participants were familiar with the Internet using it several times a week (6%) or even daily (90%). Most participants were experienced with online shopping using online stores several times a month (36%) or several times a year (39%). Twenty-one percent were rather unfamiliar with online stores, using them only once a year or less.

3.1.2. Materials

Online store and implementation of design conditions: An online store with navigation, product listing pages and shopping basket was programmed. The presentation format was automatically manipulated on the product listing pages by the system. Subjects in the matrix condition format was automatically manipulated on the product shopping basket was programmed. The presentation online store with navigation, product listing pages and

3.1.3. Procedure

Starting from an introduction page, participants were randomly assigned to one of the two experimental conditions and directed to the online-shop application. Each shopping trial started with a page showing the shopping task. The tasks were displayed in a randomized sequence to counter sequence effects. Then, by clicking on a product category in the menu, the product listing page was displayed. When the participants were satisfied with their selection they could proceed to the next task by clicking on a “Next Task” (German: “Naechste Aufgabe”) button shown below the shopping cart on the right-hand side of the page. After having fulfilled the 10 trials, users were directed to the second part of the study; this consisted of the online mental workload assessment and the demography items page.

3.2. Results

In order to assess the effects of presentation format, univariate ANOVAs were conducted on all objective and
3.2.2. Main dependent variables

offers taken (cf. Table 1). For number of items, position of the chosen products, and were found. Also, no significant differences were found of shopping experience on the main dependent variables of subjective measures presented in Table 1. An alpha level of 0.05 was used for all statistical tests.

3.2.1. Control checks

Gender: Significant differences in gender distribution over the two conditions where found using Fisher’s test \((p = 0.009)\). Therefore, the effect of gender on total cost, NASA-TLX, and satisfactions was analyzed using one-way ANOVA. No significant differences were found. Shopping experience: significant differences in participants’ online shopping experience between the two conditions were found using \(\chi^2\) test, \(p = 0.019\). Nevertheless, no effects of shopping experience on the main dependent variables were found. Also, no significant differences were found for number of items, position of the chosen products, and offers taken (cf. Table 1).

3.2.2. Main dependent variables

All means, standard deviations and test statistics can be found in Table 1. Significant effects for presentation were found for total cost and for NASA-TLX. Participants in the list condition spent less money in the tasks and felt less mental workload during task completion.

3.3. Discussion

Our findings suggest that providing the list presentation format for product listing pages instead of matrix format has positive effects on users’ perceived cognitive load. The differences found in total cost suggest that the presentation format influences participants’ product selection.

The task of buying a specific amount of a product from a product category is complex. Users have to compare different products from a cost–benefit perspective and may also take into account attitudes towards specific brands. Matrix presentations spatially and visually separate products from each other whereas list presentations relate different products to each other by organizing product pictures and attributes into columns. Our data support hypotheses H1 and H2, suggesting that the list presentation format supports comparing activities: study participants reported less mental workload and at the same time made more cost–benefit selections, resulting in lower total cost.

The analysis of the control variables (number of items purchased, serial position of the chosen items, and number of offers taken) showed no significant effect of the presentation formats. Thus, we may safely assume that the results on total cost are not artifacts produced by the usage of very specific selection heuristics. Instead, we assume that more effective and economic product comparison activities in the list presentation mode account for the differences in total cost. With these assumptions in mind, a second study using eye tracking methodology was conducted in order to gain insights into the users’ comparison activities.

4. Second study: eye-tracking experiment

4.1. Method

The procedure of the first study was adapted to the eye-tracking laboratory. Twenty participants were randomly assigned to either matrix \((n = 10; f = 8; \text{age: } M = 22.4, SD = 4.1, \text{range = 16–28})\) or list \((n = 10; f = 6; \text{age: } M = 23.5, SD = 6.6, \text{range = 16–38})\) presentation mode.

Eye-tracking was conducted with the non-invasive Eye-tracker Tobii 1750 and the analysis software Tobii Studio 1.2.3. Each product field was defined as a separate area of interest (AOI) starting from the upper left (1) down to the bottom right product (12) for the matrix condition and the serial positions for the list condition, starting with the topmost

<table>
<thead>
<tr>
<th>AOI</th>
<th>Time to first fixation M (s) (SD)</th>
<th>Number of fixations M (SD)</th>
<th>Fixation length M (s) (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.01 (0.08)</td>
<td>17.80 (4.75)</td>
<td>6.04 (1.64)</td>
</tr>
<tr>
<td>2</td>
<td>1.29 (0.39)</td>
<td>11.72 (4.20)</td>
<td>3.87 (1.64)</td>
</tr>
<tr>
<td>3</td>
<td>4.89 (1.65)</td>
<td>12.71 (5.30)</td>
<td>4.53 (2.02)</td>
</tr>
<tr>
<td>4</td>
<td>6.95 (2.93)</td>
<td>8.84 (4.52)</td>
<td>3.08 (1.67)</td>
</tr>
<tr>
<td>5</td>
<td>10.60 (3.22)</td>
<td>8.13 (5.48)</td>
<td>2.93 (2.04)</td>
</tr>
<tr>
<td>6</td>
<td>13.12 (5.35)</td>
<td>5.00 (2.81)</td>
<td>1.93 (1.08)</td>
</tr>
<tr>
<td>7</td>
<td>15.56 (5.24)</td>
<td>5.60 (3.50)</td>
<td>2.09 (1.45)</td>
</tr>
<tr>
<td>8</td>
<td>16.18 (5.97)</td>
<td>3.51 (2.34)</td>
<td>1.30 (0.99)</td>
</tr>
<tr>
<td>9</td>
<td>15.35 (5.70)</td>
<td>7.26 (3.94)</td>
<td>2.57 (1.43)</td>
</tr>
<tr>
<td>10</td>
<td>16.85 (5.00)</td>
<td>5.27 (2.66)</td>
<td>1.74 (0.89)</td>
</tr>
<tr>
<td>11</td>
<td>16.86 (6.76)</td>
<td>7.44 (3.43)</td>
<td>2.55 (1.20)</td>
</tr>
<tr>
<td>12</td>
<td>18.52 (6.91)</td>
<td>4.09 (2.26)</td>
<td>1.28 (0.73)</td>
</tr>
</tbody>
</table>
product as AOI 1, respectively. The order of fixated products was determined by ranking from the shortest to the longest time to first fixation duration. All data represent averaged values from 10 tasks per participant.

4.2. Results

4.2.1. Scanpath

In the list condition, the products were generally fixated from top to bottom (cf. time to first fixation in Table 2; sample scanpaths see Figs. 3 and 4). Products in matrix presentation mode were scanned from left to right and top to bottom (like reading a book, cf. time to first fixation reported in Table 3).

4.2.2. Number of fixations and fixation length

On average, each product was fixated at least four and up to almost 18 times whereas fixation count decreased from top to bottom. The top six products were fixated between two and six seconds each, whereas lower products were fixated between one and two-and-a-half seconds. For an overview of the averaged measures see Table 2. Fixation length (list: $M = 2.83$, $SD = 1.10$; matrix: $M = 2.1$, $SD = 0.75$), $t(18) = 0.99$, $p = 0.17$ (one-tailed), and number of fixations (list: $M = 8.11$, $SD = 2.93$; matrix: $M = 6.70$, $SD = 1.87$), $t(18) = 1.29$, $p = 0.11$ (one-tailed), did not differ between list and matrix condition. At first view, i.e. without scrolling down, only the first six products were visible. For this reason further analyses were conducted...
including only these first six products. Independent $t$-tests revealed that the list condition ($M = 10.70$, $SD = 3.63$) triggered significantly more eye-fixations than the matrix condition ($M = 8.36$, $SD = 1.94$), $t(18) = 1.80$, $p = 0.045$ (one-tailed). No significant differences were found for fixation length (list: $M = 3.73$, $SD = 1.30$; matrix: $M = 3.06$, $SD = 0.90$), $t(18) = 1.31$, $p = 0.10$ (one-tailed).

### 4.3. Discussion

Results show that across all participants every product was fixated during task performance. However, eye movement analysis shows that, as expected, scan paths differed in the two presentation modes. In list presentation mode, products were scanned in line from top to bottom. Products in the matrix mode, however, were inspected in a zigzag pattern from the top left to the bottom right. There was no difference between conditions of fixation length and number of fixations when all 12 products were compared. Hence, hypotheses H3 and H4 were not supported when all 12 products were included. However, further analysis showed that in list presentation mode the first six products were fixated more often than in matrix presentation mode. Fixation length, though, did not differ between conditions for the first six products. When including only the first six products our data supports hypothesis H3 but not H4. The bigger number of fixations in the list presentation condition (supported H3) supports...
the assumption that the list mode facilitates or even encourages comparison of products, which could explain why participants in this condition were more economic, i.e. spent less money for solving the tasks, in the first experiment. The two different presentations modes did not effect fixation lengths (disproved H4). Products were assumably processed about the same across conditions. Accordingly, presentation mode does not seem to influence the processing of single products but only has an effect on comparison between them.

5. General discussion and implications

In the first study, we found that participants in the list mode performed better in terms of more economic shopping behavior and less cognitive load experienced during task fulfillment. Matrix presentation resulted in more expensive purchases. These results were further analyzed in the second study using eye-tracking technology. Participants in the list and the matrix mode fixate all products regardless of their position. In the matrix condition, however, products were fixated less frequently than in list presentation mode. We assumed that the list presentation mode facilitates product comparison activities. This assumption is supported by performance data, like total cost, in the online experiment as well as by the increased number of fixations gathered in experiment two. Comparison activities are accompanied by an increased number of eye fixations as shown in an early study by Russo and Leclerc (1994): they found three stages to be involved in decision making based on eye-tracking analysis. The first stage is characterized by orienting and scanning the whole set of alternatives. The second stage is characterized by a large number of eye fixations needed for comparison among alternatives and elimination of unwanted items. The third stage is devoted to verification of the choice and only few eye fixations are executed. Higher number of fixations are often seen to reflect higher amounts of mental workload, which seems to be contradicting with the workload data gathered in the first experiment revealing lower mental workload for list presentation. However, when decision making and comparison is facilitated by design, the website may serve as an external memory accessible with an increased number of eye fixations. Non-facilitating designs instead force the user to use working memory in order to store product features and may even lead to psychophysiological reactions (Tuch et al., 2009). The present study shows a superiority effect for the list presentation format, at least for tasks which involve comparing different products. This seems to be true even when scrolling is needed to compare different products: our data about the serial positioning of the purchased items show that participants chose their products from the entire product set, in both the list and the matrix presentation. Further research is needed to identify the role of cognitive load in tasks where comparison is not intended or visual proximity of items might interfere with the task: searching for a birthday gift or comparing products across different online stores might be examples of tasks where list presentation might not be suitable.

At first sight, the results on the list format seem to be beneficial for customers only. Actually, list presentation supports comparing activities. In this study, this resulted in lower total cost due to the fact that the products differed only in quantity and price. Quality and “features” were not cost relevant. But comparability is an important factor when features, quality and price differ. In these cases shop owners may use comparability to accentuate features: customers might say “ok, this products costs 80$ less, but my very important features x, y and z, are not included”.

This raises the question of how these presentation modes can co-exist on E-commerce websites, when the needs of customers are twofold: some customers will search, some will browse, and others may switch strategies. Hong et al. (2004b) suggested detecting which task the user is trying to fulfill (e.g. if customers enter “Nikon D70s” in the search box they are most likely searching for a very specific product) and, based on that, show either matrix (as for the example above) or list format. We believe that a task detection approach is very difficult to implement and will never reach sufficient accuracy: In the example above, an amateur photographer might want to compare different bundles, i.e. camera body versus camera with different lenses and pouch bundles. In task detection systems, it will be difficult for the user to form expectations about the page design due to constant and unpredictable format changes. Based on these thoughts, we suggest to meet user expectations and to put them in control: (1) Search results are expected to be delivered in list format. (2) The presentation format for menu navigation results and search results should be adaptable with one click. Apple’s iTunes serves as a good example: searching, browsing, sorting and changing the presentation format are integral parts of the user interface and allow the users to display songs in the format they like best for the current task.

The focus of our study was to examine the effects of matrix and list presentation mode on consumer behavior and cognitive load. These modes represent only a small but important part of product listing design alternatives. Comparison tables and emerging formats such as the carousel should be examined and optimized to serve users’ needs. Additionally, we focused on tasks which involved searching and comparing different products. Current sales strategies try to boost browsing behavior and upselling by means of recommendations and category pages. Future research should try to provide sales and marketers with findings on user behavior and needs in browsing tasks.

References


