

# Intelligibility of Responsive Webpages: User Perspective

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**Abstract**— Nowadays, websites are considered to be responsive as a matter of course. Relatable literature focuses on the technical implementation of the associated changes and rarely addresses the potential negative usability implications. Therefore, this article addresses user expectations concerning the presentation of a website on different devices. A series of experiments focusing on selected visual and functional aspects of a website requiring adaptation is presented for this purpose and their findings are discussed.

**Keywords**-RWD; responsive; webdesign; mental model; user tests; usability; user experience; first-click-test.

## I. INTRODUCTION

Responsive Web Design (RWD) can enhance user experience significantly – but it can also be detrimental. If a user knows the presentation of a website from a particular presentation environment, then modifying that website to a different presentation environment may cause, for instance, a loss of orientation [1][2]. A standardized realization of responsive behavior could counter such effects to some extent. However, responsive behavior may strongly depend on application context and device-specific constraints, and thus be highly diverse. This might explain why standards such as DIN EN ISO 9241-151 recommend to consider contextual aspects for user interface design, but provide few hints regarding the realization of responsive behavior. Platform-specific user interface guidelines (e.g., [3]) fill this gap to some extent, but cannot necessarily be applied to manufacturer-independent scenarios.

The rest of this paper is organized as follows. Section II addresses related work. Section III deals with the performed usability tests in context of this article. The results and goals of these tests are discussed in Section IV.

## II. RELATED WORK

Human expectations (or behavioral patterns) relate to so-called “mental models”, a central concept of human-computer interaction [4]. Such models assume that humans compile personal experiences into abstract models, which are then used to predict real-world behavior. Based on the stored knowledge a quick interpretation and reaction to external and internal events is possible [5]. Therefore, a presentation and interaction model of a website, which is close to the user’s mental model of that site, can support understanding and operation [6][7] and may contribute to an anticipatory design process [33].

Acquiring a mental model can be challenging. People do not have access to their entire belief structure. Consequently, they have no direct conscious access to the mental model they have constructed from previous experiences. Thus, an interview may result in an incomplete or wrong model [8]. Therefore, hints concerning users’ mental model of a responsive web page’s behavior must be acquired in a different way. To some extent, this is addressed by studies investigating the usability of responsive webpages (e.g., a webpage for a conference [31] or the tourism domain [32]). In order to continue such efforts for a wider application focus, the work presented in the following combines research concerning current trends in responsive behavior with experiments in a given application (a web page concerned with job offers) and results from cognitive science.

## III. EXPERIMENTS

The following experiments share the primary goal of improving the understanding of today’s users’ mental model of responsive web pages. Derived goals include insights to the relevance of device-specific features for the mental model and people’s understanding of responsive behavior.

TABLE I: AGE AND GENDER DISTRIBUTION OF THE USABILITY TEST PARTICIPANTS

	Survey	Preference-Test	First-Click-Test
Quantity	70	20	50
18 to 24	17%	20%	31%
25 to 34	43%	20%	51%
35 to 44	6%	20%	0%
45 to 59	23%	20%	10%
60 and older	11%	20%	8%
Male	43%	60%	41%
Female	57%	40%	59%

### A. Preparation

A preparatory study targeted user expectation concerning responsive behavior, which are likely due to the widespread adoption of responsive design. Based on the 30 most visited websites in Germany (category: online shops and news sites) [9][10][12], an analysis on the visualization of websites on different devices was conducted. Its focus was on position and presentation of the main menu. In summary, this analysis indicates a wide adoption of changeable menus. In desktop format, 80% of the menus are positioned in the upper area,

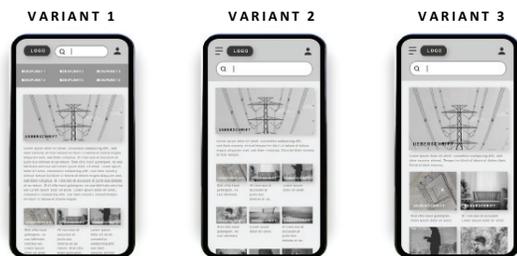


Figure 1. Three different mobile variant options.

followed by positioning on the left with 40%. The smaller the device, the more this distribution changes. On smartphones, for example, 63% of the menus are positioned on the left. On small displays, 90% of the menus are displayed in form of a hamburger icon. The format of the menu usually stays consistent and is not affected by how the device is held in vertical or horizontal format.

## B. Survey

To get a basic understanding of users themselves in the context of RWD, a survey conducted via an online form was performed (see Table 1, column “Survey”).

### 1) General web user capabilities

All subjects stated they are competent in the German and 83% also in the English language. The older the participants are, the more their ability to understand English terms decreases. After the age 45, the English skills drops from 96% to 58%. To ensure users understand website texts, English expressions should be avoided as the age of the target group increases.

Next, the participants were asked, which devices they have that can enable website access. 97% said they own a smartphone, followed by a laptop with 79% a tablet with 64% and desktop computer with 43%. The survey also revealed that older subjects are more likely to own a tablet device than a laptop. They also prefer to use a combination of tablet and smartphone, while the younger generation tends to use a smartphone and laptop. The older subjects' preference could be explained with the more intuitive human-computer interaction of the tablet compared to desktop computers. Especially for people with special needs, such as a limited field of vision, this is attractive. This includes, among others, the older generation [11].

With regard to the operation of the various devices, the majority of users rated themselves as confident to very confident (e.g., 81% in operating mobile devices). Older test persons tended to give a poorer estimate of neutral to confident. This can probably be attributed to the time spent using websites. While the younger participants stated that they spent an average of two to four hours a day on websites, the older generation spent just under one hour. In addition, the fundamental experience with the digital world plays a role here (digital immigrants) [13].

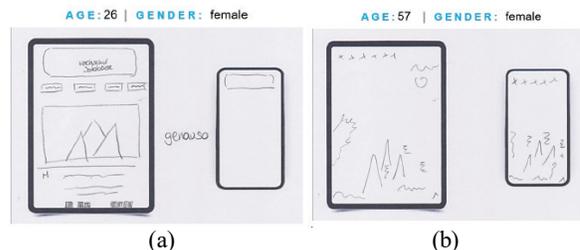


Figure 2. Mobile version sketch of a young (a) and an older participant (b).

## 2) Web user expectations

This test showed that good usability and uncomplicated navigation were particularly important website features to all participants. Furthermore, it showed that a fast-loading time is especially relevant for younger test persons. Whereas for older participants it is uncomplicated navigation.

Based on the laptop representation of a website, participants were asked to choose one of three given mobile variants (see Figure 1). Variant 2 in Figure 1 is visually most similar to the initial device, but to match the desktop look, the text was shortened. The test persons are therefore mostly unaware that a change has been made, because only variant 1 is unchanged. The majority of the participants chose variant 3, in which changes were made to both the content and the layout. It is assumed this decision is made based on experience (mental model) [14].

## 3) Comprehension for adaptive behavior

In general, most participants indicated an understanding of website visual customization. When it comes to changes in function, the results are different. Here, more than half of all subjects had no understanding for adjustments. Nevertheless, only 21% said that an understanding of website customization is very important to them. In contrast, 74% stated that reaching their goal for visit the site quickly, was very important to them. This suggests that the scrutability of a website customization is irrelevant to the participants if it helps them reach their destination faster.

## C. Preference test

A preference test in form of an interview was realized [15]. Since a small number of respondents was expected, an even distribution of age groups was chosen for the test persons (see Table 1, column “Preference-Test”).

### 1) Visualizing web users mental model

Based on a printed screenshot of the desktop version of the start page of Hochschuljobbörse [16], participants were asked to outline its tablet and smartphone version. Figure 2 shows sketches of two participants. These sketches reveal that younger test persons are aware of the entire website. The respondents only adapted the content to the width of the device without changing the data itself. For display on a smartphone, expectations differed. Some participants expected an identical presentation on the smartphone as well as on the tablet (see Figure 2 (a)). Other respondents changed

the layout of the website and adapted the content to the compressed display size. Although all test persons received the same instruction, some participants only focused on sketching the big image. The test showed that this behavior only occurs among older test persons.

This observation may relate to human brain evolution. An impact on the executive function can be expected with increasing age. Part of this is the control of attention, which is used to perceive external stimuli. Some stimuli are noticed instinctively; others require awareness and attention [17].

Due to these findings, we assume that the triggered stimulus of the image might be too strong for older participants. As a result, they were less aware of the other web elements shown. Beyond, these observations suggest that a single mental model can hardly represent the expectations of all age groups.

### 2) *Expectations on content and layout*

The participants were presented the desktop version of a dummy website and had to choose one of two given mobile versions. 65% favored a customized version with shortened text, cropped images, and the menu as a hamburger icon. The older the respondent was, the stronger the preference was for the unchanged version.

Furthermore, 95% of users want access to all content, regardless of what device is used. If this is not realizable (e.g., small display) the participants preferred additional pages over reduction. An opposite result was obtained for the adaption of the layout. When switching the device position, 35% of the respondents prefer an unchanged layout. These participants called the reason for "being used to" this. Due to a changed device orientation, the website layout is not adjusted here either. In this Case, 65% preferred a change in the data layout for an improved overview.

Additionally, the participants were asked about the presentation of texts and images on different display sizes. Their responses indicated that they were generally unwilling to read texts on digital devices. For images, the relevant elements depicted should be easily recognizable. Furthermore, a good overview of the site content should also be guaranteed. Beyond, the larger the screen area the more images and text should be displayed. However, one test participant reported that he prefers reading text on large surfaces – but uses a smartphone for reading in the first place. The readiness of mobile devices might explain such contradictive behavior [18].

### 3) *Mouseover effects*

Mouseover effects can be used to highlight interactive elements. Most of the test persons perceive these effects as positive. Mouseovers also frequently display tooltips. This additional data cannot be activated on devices without mouse input. As mentioned before, web users want access to the same information no matter which device they use. By applying tooltips, this is not given. In summary, the use of this additional information should be applied wisely, or an alternative presentation should be considered for other input techniques.

### 4) *Device orientation*

Asked for their preferred device orientation of mobile devices, 90% answered they mostly use their smartphone vertically. Also among the six typical cell phone holding positions, the phone is only horizontal in one [19]. In contrast to the smartphone, the participants in this preference-test preferred to operate the tablet primarily horizontally. Explained can this by the similarity to the desktop presentation. Some Internet users already use the tablet as a laptop replacement. With the help of magnetic keyboards, the tablet can be quickly converted into a mini laptop at any time [20].

### 5) *Expectations on menu*

According to the test participants, there should be an everlasting access to the menu. However, for smaller display areas, menu fixation can be counterproductive. Often the browser buttons require a lot of screen space. Sticking the website menu in place reduce the area for displaying the content, this way interactions may become harder to perform. For example, scrolling requires a certain space to perform the desired gesture. If this area is small, this can become difficult [21]. Taken together, this suggests avoiding fixation of menus on small displays.

In addition, the participants were asked to evaluate navigation elements that can appear and disappear compared to a permanent presentation. With large display areas, all participants favor the permanent version. On devices with small display, a collapsed menu variant is preferred. In relation to a changed device orientation, the menu display should remain constant in the opinion of the users, especially older participants. Younger users prefer a changed menu presentation, when all menu items can be shown directly.

Furthermore, instead of overwriting menu items, the respondents preferred an extension with sub items. They explained this with the possibility to compare menu options. Jumping back and forth between different subpages will also be avoided. Only two users disagree to the addition of menu sub items. They stated an overload resulting from the choice of elements. This phenomenon is called Paradox of Choice. Paradox since a larger selection is intuitively regarded as positive. In practice, however, too many options can be considered difficult or frustrating [22][23].

### 6) *Thumb zone*

Subsequently, the participants should define the menu placement they expect on different devices (out of 6 predefined menu positions). For the laptop and tablet (vertical and horizontal), the menu in the upper area received most votes, followed by the arrangement left. Similarly, most smartphone users prefer the menu at the top and left. A few expected the arrangement at the bottom of the screen. One of the respondents justified this decision with the phone's handling. He unconsciously refers to the so-called thumb zone. The thumb performs most phone interactions. As a result, only one third of the screen, the so-called "thumb zone", can be reached effortlessly. For frequently used interaction elements (which are not limited to menus [21]), it

is therefore recommended to place them within reach. For smartphones, this means at the bottom of the page.

In summary, from an ergonomic point of view, placing a menu at the bottom can lead to an improvement in usability. This additionally makes clear, that the mental model alone does not increase the usability of a website.

#### D. First-click-test

As the name suggests, a first-click test analyzes the users' first click on a user interface [24]. The probability of successfully completing a task on a website is twice as high if the first click was correct [25]. The first-click-test of this article (see Table 1, column "First-Click-Test") was set up in the form of the A/B-test concept [26].

For Original Version A and adapted Version B, the web presentation of the Hochschuljobbörse was used again. In the context of this article, the focus lies not only on the correct click but also on the time needed for it. Consequently, it can be identified how far the composition of the website corresponds to the mental model of the test person.

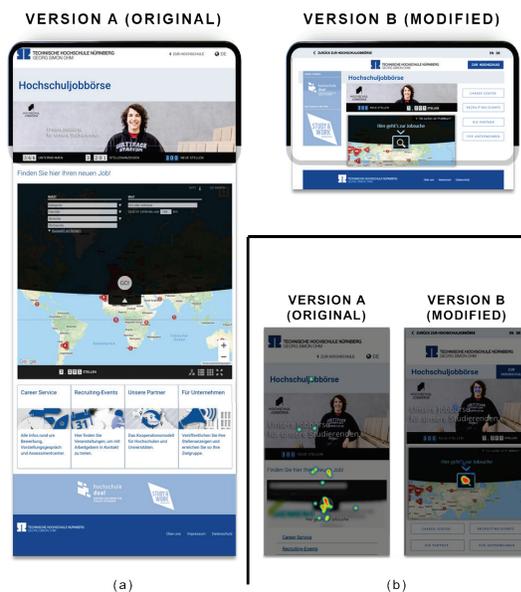


Figure 3. Horizontal (a) and vertical (b) smartphone version of the job search subpage.

##### 1) Right amount of information

Different results between the test versions can already be seen in the first task. The respondents in the original version A found the menu 5 seconds faster on average than the respondents in version B. Due to the compression in Version B, more elements are visible on one display area. As a result, the viewer may be flooded with information, which influences the information processing.

With increasing information input, the performance of human information processing increases linearly up to a threshold value. Above this threshold, however, performance degrades dramatically [27].

Consequently, more information input does not always have a positive effect for the viewer. However, avoiding

information overload should not result in too less displayed information. These negative effects can be shown by looking at the results of the mobile representations.

In the horizontal position (see Figure 3 (a) right), the layout of the page has not been adapted to the changed device position, instead it has simply been scaled. The header image is enlarged to such an extent that the user can hardly recognize any further information. Consequently, the user lacks an overview of the site. In the modified version B, the layout was changed to fit the new device position (see Figure 3 (b)). As a result, nearly the same number of elements are displayed in both orientations. Thus, the sum of the information to be processed does not change or only minimally for the viewer. Due to this, respondents in test version B find the searched element three times faster than participants in group A.

##### 2) Webpage length

As can be seen in Figure 3 (a), the page length is minimized by adjusting the layout. Consequently, participants had to perform fewer interactions to retrieve the desired data. This may also be a cause for the quick finding of the searched element. However, shortening the page length does not generally improve the user experience. For example, hiding content in order to reduce page load time [28] may shorten a webpage. A first-click test showed that participants needed 13 seconds longer to find a partially hidden section. This time loss is high when compared to the desired performance improvement [28]. Collapsing small elements should therefore be avoided.

##### 3) Orientation and recognition

If the user can process the information presented more quickly, he or she will also orientate faster on the website [27]. The test also showed that the users' orientation can be guided with the help of highlighted elements. By highlighting, users found the desired element 5 times faster.

Additionally, a familiar presentation of interactive elements allows the user to recognize these faster. If a click is not followed by the expected action, a user may get frustrated. This effect can be reduced by following web design conventions. For example, buttons should be designed as rectangles with a three-dimensional appearance [29]. As a result, web users not only recognize interactive elements better, but the subjects of this test also clicked more precisely on the correct them (Figure 3 (b)).

The findings of this test further suggest the use of "anchor points" that do not or hardly change their position and form, regardless of the layout or design of the page. How relevant such an anchor can be is shown in the mobile version of the job search window. In Figure 4 (b), the light blue header represents this anchor with a button to return to the previous page. In the original version A (see Figure 4 (a)), all test subjects wrongly chose the X in the upper left corner of the browser window which closes the window instead of the correct one in right bottom corner.



Figure 4. Vertical smartphone version of the job search formular subpage.

In addition, the test subjects needed an average of 16 seconds for this incorrect decision. Due to the everlasting anchor in the form of the header, the participants of group B needed only three seconds to click on the correct button.

#### 4) *Popups*

Pop-up windows offer a way to convey important information without losing the context of the current screen [30] and to attract the user's attention. However, this may be disadvantageously for the user. For instance, if the user wants to search for a job at the Hochschuljobbörse website first a window with internships information pops up. Once closed, however, the user can no longer access the pop-up without reloading the page.

To avoid such potentially confusing behavior, both test groups were asked to assess a modified version of the web page, where information about internships is not directly visible or overlap with the job search form. Only a field that refers to further information is displayed. In both test groups, most participants opted for no overlap version.

#### 5) *Menu features*

A mental model can be changed, which is shown by the mobile menu presentation of the test. In the original version, the menu is presented as a hamburger icon and the position is unchanged (in the middle under the header). Based on the website analysis, menu icon is predominantly positioned in the top left corner. This placement was presented to the participants of the modified test variant B. Although the original version deviates from the usual arrangement, the subjects recognized both menu variants at the same rate. This suggests that the participants adjusted their mental model based on the desktop variant shown earlier.

Participants were also asked to choose one of two smartphone menu variants (seen in Figure 5). In test group A (see Figure 5 (a)), 96% opted for variant 1. The majority in group B (see Figure 5 (b)) also voted for version 1, but only 57%. Reasons for this can be found in the preference-test results. Users indicated to prefer the overview of all menu items. Since the menu items of test version A, variant 2 do not fit on one screen area, the participants presumably opt for variant 1. The reasoning is again confirmed by the narrow decision of the participants of group B. This is because all items are clearly visible on the screen in both versions. The fact that most of the participants in group B nevertheless tend

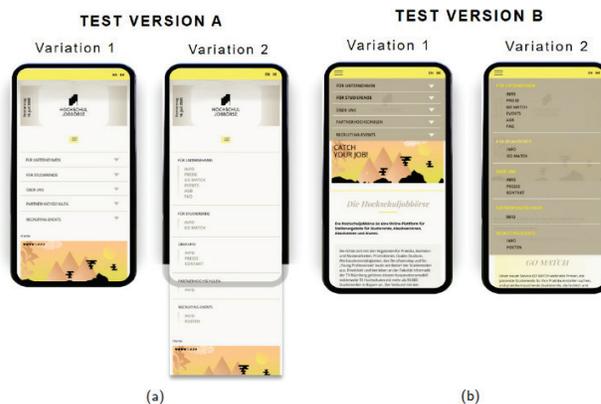


Figure 5. Mobile menu variants.

towards variant 1 can be attributed to the fact that the initially collapsed menu items prevent the user from feeling overwhelmed.

In the horizontal representation on the smartphone, the participants in test group A were shown a folded-out menu variant. Test group B still showed the hamburger icon in the upper left corner. It showed that the participants of the unchanged variant needed five seconds less to click on the menu than in the changed one. Due to the changed menu form, the user must first process the newly information, this takes time. The fact that older users emphasize with consistent menu representations (preference-test) is also reflected in this test. Participants between 18 and 34 years of age needed on average only 4 seconds longer to recognize the menu in the adapted version. For the older test subjects, it is 8 seconds more. From an information processing point of view, users benefit from a consistent website presentation.

## IV. CONCLUSION

This article seeks to providing insights to the relation between adaption of webpages and human cognition. A series of experiments indicated, for instance, that users do not notice small adaptations if they lead to a web site that looks "the same" on different devices. For fast processing of information, the right amount of information should be presented on a display surface. Due to the increasing perceptual limitations in old age, this turned out to be especially relevant for older web users. In general, the test results usually differed due to age groups. For example, while the older generation prefers a constant website display across all devices, younger web users welcome an adjustment if it improves the web experience for them.

These results are limited in the following ways. First, only German participants have taken part in the test. Since experiences may differ due to cultural background, the results in this article should only be used for the German region. Second, the results are based on purely visual experiments and theoretical questions. Third, responsiveness should not be considered as an isolated variable when assessing the general user-friendliness of a website, which is also affected, e.g., by visual design and content selection.

Future work may build on these findings in various ways. Beside additional verification of the presented results by further studies, users' changing expectations concerning adaptive behavior suggest a continuous repetition of such studies – and eventually a representation of derived recommendations able to comprise the evolution of user expectations.

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