

A Usability and Universal Design Investigation into Scrolljacking for Web Pages

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Abstract. Scrolljacking is a feature used in web development to hijack and modify the speed, direction, and overall native behaviour of scrolling on a web page. This research study investigated how scrolljacking can influence the usability and the Universal Design of web pages. Two prototypes were designed and developed as part of this research. One prototype had a non-scrolljacking user interface and the other prototype had the same user interface as the first prototype but with scrolljacking functionality. The two prototypes were evaluated in an experiment with 20 participants, where they had to perform similar task-driven actions in the two user interfaces. Accuracy, user satisfaction, and speed were some of the main aspects investigated in this experiment. To measure these aspects, the total time to complete the tasks and the number of errors made per task were collected, as well as the scrolljacking familiarity and the participants' opinions about the topics of ease-of-use control, frustration, and fun during the experiment. Data was collected during the experiment and was analysed by using paired t-tests and Wilcoxon signed-rank tests. The data analysis revealed that there was no statistically significant difference in speed between the two user interfaces. However, there was a statistically significant difference in the accuracy and user satisfaction between the two user interfaces, as the interface using scrolljacking had lower accuracy and user satisfaction scores than the non-scrolljacking interface. The research study suggests that scrolljacking negatively influences the usability and the Universal Design of a web page.

Keywords: Scrolljacking, Non-scrolljacking, Scroll Hijacking, Web Page Scrolling, User Interface Scrolling, Usability, User Experience, Universal Design, Design For All, Evaluation.

1 Introduction

Scrolling on a web page is a fundamental interaction that can take place between users and any number of web pages. Typically, the most well-known type of scrolling is the vertical kind, where one scrolls a web page upwards or downwards. Over the years researchers and designers have tried different types of scrolling behaviours. One such deviation from the well-known scrolling type is scrolljacking.

Scrolljacking also sometimes known as scroll hijacking, is simply defined by Paul [13] as: ‘...a design pattern that changes the speed and, sometimes, the direction of scrolling on a web page.’

There are some main types of scrolljacking which have certain behaviours. One kind of scrolljacking (sometimes referred to as a full jack) uses a technique to take over the entire web page, blocking the user from proceeding further until they scroll through the page. It works similarly to a pop-up, limiting the ease of scrolling back and forth between the content of the page. Another kind of scrolljacking works in a similar manner as described, but is only concerned with the background images used on a web page (sometimes referred to as a slight jack). By scrolling, the background images will be changing their position several times, creating an animation effect. Lastly, a third kind of scrolljacking involves both the background and foreground elements in a web page being affected (sometimes referred to as a fading jack). By scrolling, different elements will fade in or out of the page. This type of scrolling behavior can create white space between the content of the page.

Paul’s [13] usability test indicated that scrolljacking can negatively impact usability if certain design principles are ignored.

In our research, as far as we have been able to ascertain, there are no peer reviewed published works directly investigating the usability and universal design of scrolljacking.

Therefore, in this paper, we present the novel results of a preliminary experiment comparing identical web pages where they only differed in having scrolljacking or not as an interaction mode. Our main aims were to investigate if scrolljacking had some effect (positive or negative) on usability and universal design.

The next section will briefly consider some previous works in the area of scrolling for user interfaces. This will be followed by a description of our experiment comparing scrolljacking and non-scrolljacking. Then the results of the statistical analysis will be presented. Finally, a discussion with conclusions will complete the paper.

2 Background

Scrolling is a part of many user interfaces in applications and web sites. Over the years different kinds of scrolling approaches have been used. Some have been extensively investigated, while some approaches have not been well investigated.

One approach that has been investigated is parallax scrolling. In Mahardika et al. [11] the authors investigated parallax scrolling. Their testing environments were storytelling and online shopping. From the data collected they concluded that web pages designed with parallax scrolling fostered faster task times and more user engagement. However, it must be noted that the results are aligned to goal-oriented web pages that contain a lot of text. Also, since their work used a between-users design, it is unclear if any bias resulted from differences in the participant sample. Particularly since full details about the participant sample are not given to the reader [7].

However, Murano and Pandey [12] also conducted a study into parallax scrolling and found no statistically significant differences in terms of task times and user

preferences in the context of using a restaurant type web site. The overall averages in that study though indicated that task times were faster with the non-parallax web pages. Subjective preferences on average were in favour of the parallax web pages. However, the study had a rather small sample size.

Other scrolling types, such as infinite scrolling, have also been investigated by other researchers. Issues of effectiveness and user satisfaction with infinite scrolling are still unclear. However, Loranger [10] suggested that when user tasks are goal-oriented, infinite scrolling is not the best design option. Further, task-driven actions can negatively affect user experience if one is obliged to use infinite scrolling.

Linked to this, Sharma and Murano [14] carried out a study into infinite scrolling, where an experimental evaluation was conducted. They compared four identical prototype web sites, which varied only by the scrolling method. The scrolling methods were 'normal scrolling with default pagination, infinite scrolling, infinite scrolling with a load more button and infinite scrolling with pagination, [14]'.

The authors did not observe any statistically significant differences in terms of task times and errors across the four scrolling types. User experience aspects did not reveal such a clear picture, where opinions were varied in relation to scrolling types [14].

Other less well-known approaches to scrolling have also been investigated in the recent past. Ishak and Feiner [5] investigated 'content aware scrolling', which depending on the content of a certain document, affected the direction of scrolling, the speed and zooming. The authors reported positive informal experiences with this approach.

Also, Bartlett [2] investigated a mobile device option which allows users to use gestures for achieving scrolling, selections and commands. This development meant that other options, e.g. touch interaction were not required. Although mention is made about some kind of testing/evaluation, the details about this are not included in the paper and therefore it is difficult to ascertain any usability outcomes.

In addition, Aceituno et al [1] investigated various kinds of edge scrolling techniques. They concluded that edge scrolling is in use by some users and that users tend to know about some of the negative issues with the use of edge scrolling. They also found that different implementations of edge scrolling affected performance and how users felt about the level of work involved.

In considering universal design or design for all, Darzentas and Miesenberger [3] some years ago suggested that those involved with information technology and design need to be more engaged and on-board with design for all issues. These observations of some years ago are still relevant, as more recent studies indicate that universal design failings continue to occur on a large scale [4].

This brief selection of related works indicates that for some years researchers have been investigating and trialing different kinds of scrolling. The previous works' results overall tend to be quite mixed in nature and many require further work to concretise initial results. The previous works also continue to indicate failings in the area of universally designed systems. Furthermore, it is indicated in the previous works that peer reviewed and published results on scrolljacking in terms of usability and universal design are lacking. We therefore present in the subsequent sections an experiment and results that aimed to find out if there were any differences in performance and user experience with scrolljacking compared to non-scrolljacking.

3 Experiment

3.1 Experiment Design

A within-users experimental design was chosen for this evaluation. We wanted participants to experience both types of scrolling and therefore be able to make judgements on the impressions gained for both scrolling types.

Figure 1 shows a condensed screenshot for the home page. Both implemented versions of the web site were identical in all aspects, except for the scrolling functionality (non-scrolljacking or scrolljacking).

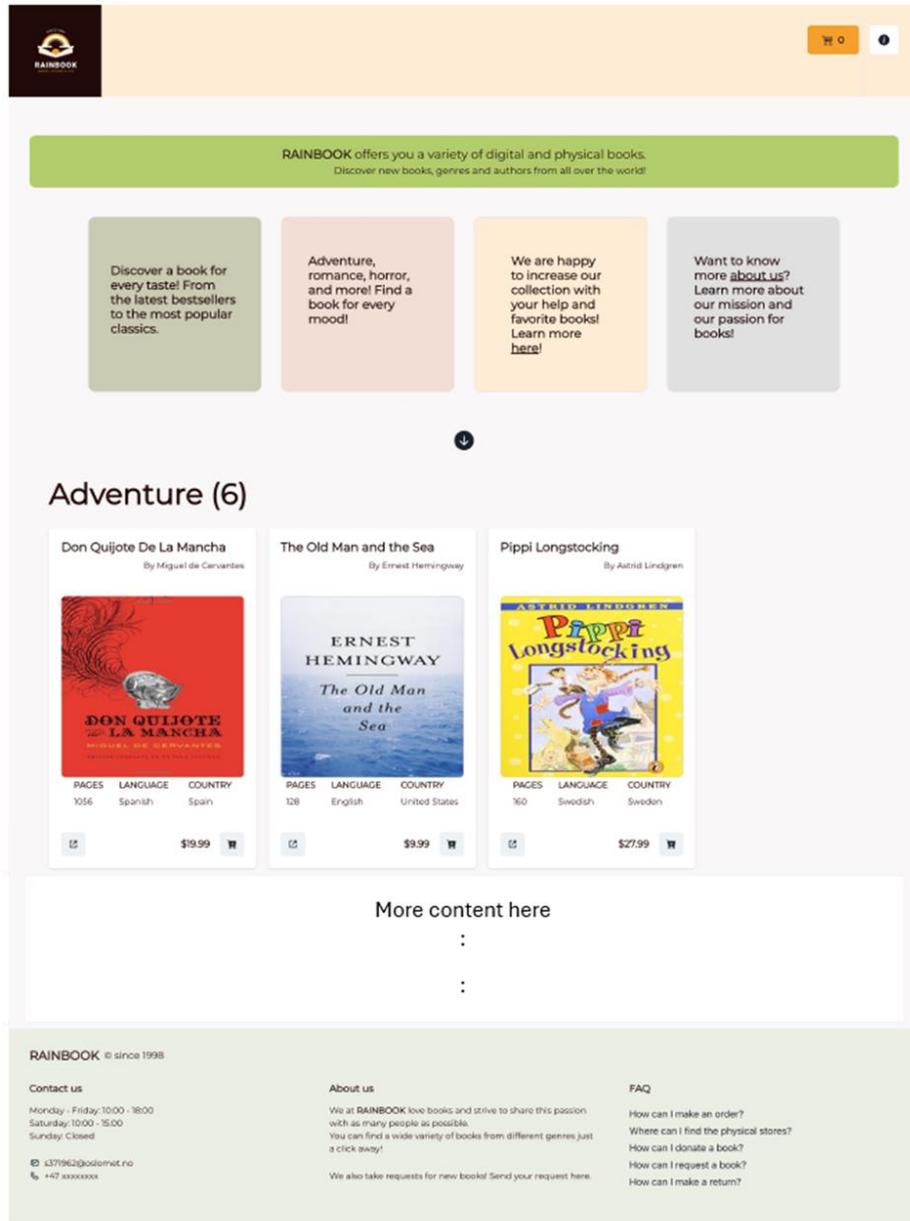


Fig. 1. Home page of the prototypes showing the layout used and how books were displayed.

3.2 Hypotheses

We had three hypotheses we wished to examine:

H₁: For errors, there will be a statistically significant difference between the scrolljacking and non-scrolljacking user interfaces.

H₀: For errors, there will be no statistically significant difference between the scrolljacking and non-scrolljacking user interfaces.

H₂: For task execution speed, there will be a statistically significant difference between the scrolljacking and non-scrolljacking user interfaces.

H₀: For task execution speed, there will be no statistically significant difference between the scrolljacking and non-scrolljacking user interfaces.

H₃: In terms of user satisfaction, ratings scores will be statistically significantly different and verbally expressed differences and observations will differ, between the scrolljacking and non-scrolljacking user interfaces.

H₀: In terms of user satisfaction, ratings scores will not be statistically significantly different and there will be no verbally expressed differences and observations, between the scrolljacking and non-scrolljacking user interfaces.

3.3 Users

Twenty participants were chosen for this study who were linked to the Information and Communication Technology area. The participants were familiar with using a computer and the internet. Most participants (18) had never heard of scrolljacking, while one participant knew about scrolljacking and one other participant expressed a neutral opinion concerning knowledge of scrolljacking.

The sample of participants consisted of individuals from varied age groups. Six participants were in the 18-30 age group, 12 participants were in the 31-40 age group and two participants were in the 41-50 age group.

3.4 Variables

The independent variables in this study were the two different user interfaces featuring non-scrolljacking and scrolljacking interaction and the tasks.

The dependent variables were accuracy and user satisfaction.

The dependent measures were the total number of errors, the total time to complete the tasks and users' subjective opinions on their feelings of satisfaction and enjoyment.

Errors were defined as any kind of action that was done by the user without their acknowledgment, such as miss-clicking, clicking on a wrongly chosen item, scrolling when the user intended to do a different action, or not scrolling when the user intended to scroll. The total number of errors encountered per task and in the overall experiment were recorded.

Total task time involved the time to complete a single task, as well as the total time to complete the set of tasks. Each user was timed by starting a timer at the start of a task and stopping it at the end of the same task. The total time to complete a set of tasks was simply determined by adding all the times of the tasks in the set.

User satisfaction and enjoyment were measured by means of a post-experiment questionnaire which covered user-experience type topics. Further, verbal comments and informal observations were also included within the experiment and results.

3.5 Apparatus, Materials and Tasks

The apparatus and materials used were:

- An Apple MacBook M1 Pro 2021 16GB.
- An Apple iPhone XR 2018 64GB, with its native Calculator application for participants to optionally use in relation to Task 1, where some addition had to be carried out as part of the task (see Pilot Testing section for more details on this aspect).
- A Huawei Watch Fit A96, used by the experimenter as a stopwatch for task timing.
- Google Chrome browser to render the two website prototypes.
- A pre-experiment questionnaire. It contained the ethical aspects of the experiment and was used to register the consent of the participants in the experiment. The questionnaire also elicited age groups and knowledge of scrolljacking from the participants.
- A post-experiment questionnaire containing five questions related to user experience type issues. The first four questions covered aspects of ease of tasks, feelings of control, feelings of frustration, perceived fun and overall preference in terms of the scrolling type. The questionnaire elicited responses to these topics by asking participants to score their opinions on a Likert-type [9] scale. The scale ranged from 1 – strongly disagree to 5 – strongly agree. So that comparisons could be made between the two user interfaces each of the four questions was asked two times. This gave an individual score for each user interface. The fifth question eliciting overall preference for one of the scrolling types contained two options – scrolljacking or non-scrolljacking.

The post-experiment questionnaire was a bespoke questionnaire which was designed to allow participants to give their opinions in a structured manner. The five questions were designed with the main aim of giving us an idea concerning usability and universal design aspects in relation to scrolljacking designs.

The specific tasks designed are shown in Tables 1 and 2.

Table 1. Tasks used in the experiment under the non-scrolljacking condition

TASK SET 1 USED ON PROTOTYPE 1 NON-SCROLLJACKING	
Task Number	Task Description
1	From the Home Page, find how many genres the store offers.
2	From the Home Page, tell me how many pages the book titled ' <i>The Man Without Qualities</i> ' that is under the ' <i>Philosophy</i> ' genre has.
3	From the Home Page, add the book ' <i>The Diary of a Madman</i> ' from ' <i>Short Stories</i> ', ' <i>A Doll's House</i> ' from ' <i>Fiction</i> ' and ' <i>The Tale of Genji</i> ' from ' <i>Romance</i> ' in the cart and then go to checkout.
4	From the About Us Page, find information about how you can request a new book.

Table 2. Tasks used in the experiment under the scrolljacking condition
TASK SET 2 USED ON PROTOTYPE 2 WITH SCROLLJACKING

Task Number	Task Description
1	From the Home Page, find how many books the store offers.
2	From the Home Page, tell me how many pages the book titled <i>'Hamlet'</i> that is under the <i>'Poetry'</i> genre has.
3	From the Home Page, add the book titled <i>'Tales'</i> from <i>'Short Stories'</i> , <i>'The Sound of the Mountain'</i> from <i>'Fiction'</i> and <i>'Middlemarch'</i> from <i>'Romance'</i> in the cart and then go to checkout.
4	From the About Us Page, find information about how you can donate an old book.

The tasks were designed to be representative of real-world tasks one might carry out at a bookstore web-shop.

To avoid learning effects, two sets of tasks were designed with approximately equal levels of difficulty.

We aimed to maintain equivalence in difficulty for both sets of tasks by having the actions in each set of tasks of the same difficulty, where the only aspect that was changed was the context of the action (e.g., book A vs book B). Moreover, designing the tasks in such a manner helped to keep the path to task achievement the same in both prototypes. This approach aimed to limit the potential bias for learning while keeping the same level of complexity in both versions of the prototype.

In addition, the tasks, linked to the dependent measures (Section 3.4) were designed to allow collection of data that would give indications about usability and universal design aspects for scrolljacking use.

Description of the Scrolljacking Used in the Scrolljack Prototype. In this sub-section we will describe the kinds of scrolljacking that were implemented into the scrolljacking prototype.

As can be seen in Tables 1 and 2, all the tasks were centered around the Home and About Us pages. Therefore the description that follows is in the context of these two specific areas of the scrolljacking prototype. The figures presented are not intended for detailed reading, but merely to give a visual idea of the main design elements.

On the Home page, the full jack effect was implemented. While the visual presentation of the Home page was the same as in the non-scrolljacking version, the content of this page was split up into multiple individual pages. As such, the first page of the Home page was considered the part with the informational banners as seen in Fig. 2. Information points displayed on the Home page. All the subsequent pages were represented by each category of book genres. Thus, in the case of this prototype, the second page was represented by the Adventure category (Figure 3), and so on. The Home page ended with a Footer (Figure 4) as its own page.

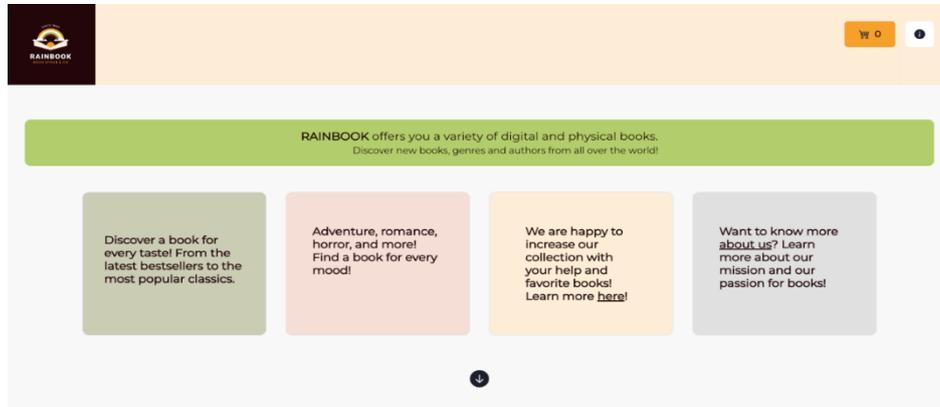


Fig. 2. Information points displayed on the Home page.

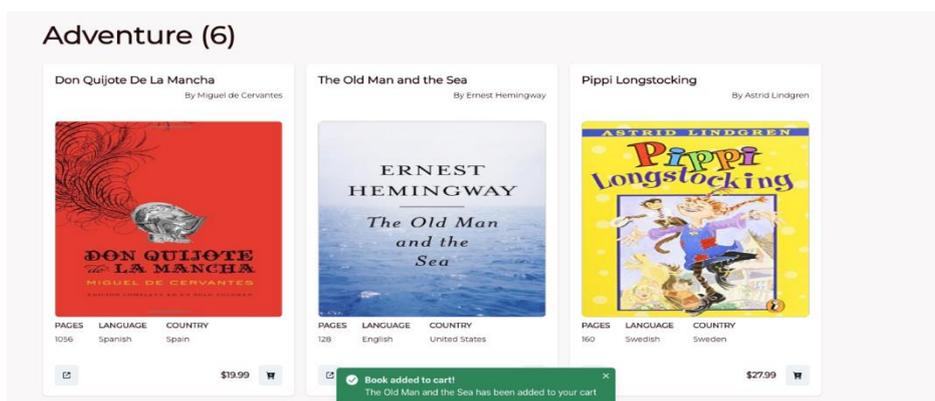


Fig. 3. A category with books on the Home page.

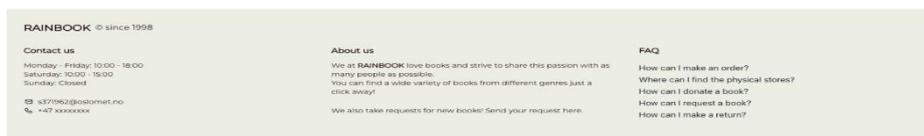


Fig. 4. Page footer.

When the user scrolls to the Home page, they will actually be scrolling between these multiple individual pages. One motion of scrolling down or up will fully load the corresponding page, removing any partial content being cut off as done usually by the native scrolling behavior. This type of scrolling effect will prevent the user from rushing between the content of the Home page, as they need to scroll through the single

small pages one by one. Skipping content will also be impossible using the full Jack effect. This means that the user will have to do the action of scrolling as many times as there are categories in the Home page to reach the end of the page.

The About Us page uses two concepts of scrolljacking, the slight Jack and the fading Jack. In contrast to the Home page, where the scrolljacking is applied directly to the page, in the About Us page, scrolljacking is applied to the content inside the page. This means that the text blocks and the images will be influenced by the scrolling motion done by the user.

The About Us page starts with a decorative section as seen in Figure 5. As the user scrolls down, the circled logo will remain in place while the two borders surrounding it will move up at different speeds, creating an animation effect using slight jack. Scrolling down even more, the user will see more text being scrolljacked by using both slight jack concepts and fading jack concepts. For the text scrolljacked using fading jack, this text will initially be hidden from view until the user scrolls down enough on the page. When this specific point is reached by scrolling, the position of the text will be continuously translated horizontally until it leaves the view again at the opposite end of the page.



Fig. 5. Decorative section in the About us page.

By scrolling more on this page, the user will enter the Informational section as seen in Figure 6. In this section, background and foreground elements have been scrolljacked, creating multiple animations at the same time. The background images will be scaled higher or lower than their initial position, creating a depth effect. The foreground images will also be scaled in the opposite direction of the background elements. Meanwhile, the foreground text will be continuously translated either from the right, left, up, or down.

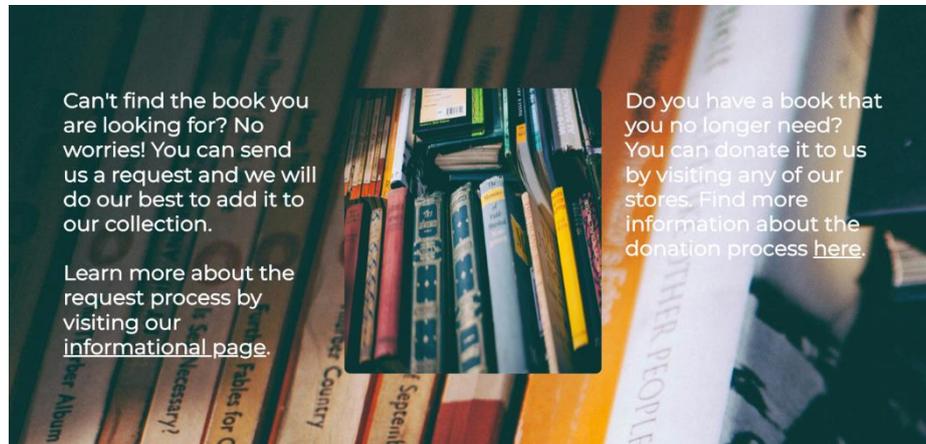


Fig. 6. Informational section in the About us page.

3.6 Procedure

Participation in the experiment was voluntary. Each participant was provided with a digital pre-experiment questionnaire dealing with informed consent related to the study and some background questions. The participants were given as much time as they needed to read and sign the consent aspects (Note: the study was conducted in line with ethical requirements for research conducted in Norway). If they agreed to participate in the experiment, a unique identification number was assigned to each individual participant. The number was used to link the experiment results with the user information. No identifying information was collected from the participants.

The experiment was conducted in a private room containing only one participant at a time and the researcher. This allowed for a controlled and quiet space while reducing unnecessary external noise or potential bias. Each individual participant was asked to complete Task set 1 followed by Task set 2 for the experiment. Use of the 'Find in page' browser feature was not allowed. During this process, participants were timed and observed discreetly by the researcher. After the set of tasks was completed by the participant, participants were asked to complete a post-experiment questionnaire with questions related to the overall experiment and their personal experiences.

3.7 Pilot Testing

The described experimental design was the final version used with the participants. An earlier version was pilot tested and a number of small improvements and additional details were achieved for the experiment.

The first aspect was that the pilot testing gave a broad indication of how long the experiment overall might last and so this information was included in the initial information given to participants.

The second issue was that the pilot testing allowed for improvement of the initial information by adding more relevant detail and better formatting.

The third aspect concerned Task 1. After the pilot testing, it was decided to supply participants with a calculator for adding up the number of genres covered and number of books. Use of the calculator was made optional. This allowed the participants to focus more on the tasks than on the actual adding of numbers.

The fourth aspect involved minor changes to the implementation of the prototypes.

The fifth aspect was to design into the procedure the prohibition of using the 'Find in page' browser feature. This was so that the interaction focused on the scrolling aspects under investigation.

3.8 Results

The data collected from the comparisons were statistically analysed for significant differences. In all cases, the data were initially analysed to determine if the data was parametric in nature. The data collected for task times was found to be parametric and was analysed using a t-test. All the other data was found to be non-parametric and was therefore analysed using Wilcoxon Signed Rank Tests. For brevity, the details of the analysis for determining whether the data was parametric in nature, is not included here. All results presented below are in two-tailed format.

Total task times were analysed using a t-test. The mean (M) task time for the non-scrolljacking user interface is $M = 4.39$ (Standard Deviation (SD) = 1.2) and $M = 4.56$ (SD = 1.01) for the scrolljacking user interface. The paired samples t-test result is not significant: $t(19) = -1.476$, $p = .156$. This is represented by a medium effect, $d = 0.32$.

Total number of errors were analysed using a Wilcoxon Signed Rank Test. The mean errors for the non-scrolljacking user interface are $M = .75$ (SD = 1.41) and $M = 4.2$ (SD = 2.783) for the scrolljacking user interface. The Wilcoxon Signed Rank Test indicates that the scrolljacking user interface incurred significantly more errors than the non-scrolljacking user interface: $W = .00$; $z = -3.842$, $p < .001$ with a large effect size ($r = .859$).

The next series of results concern the participants' responses to the post-experiment questionnaire.

For the question concerning how easy participants found the tasks under each user interface, the results are the mean score for the non-scrolljacking user interface is $M = 2.85$ (SD = .988) and $M = 2.15$ (SD = 1.226) for the scrolljacking user interface. The Wilcoxon Signed Rank Test indicates that there is no statistically significant difference between the two scrolling types for ease of the tasks: $W = 42.00$; $z = -1.656$, $p = .098$ with a medium effect size ($r = .370$).

For the question concerning feelings of control whilst using the user interfaces, the results are the mean score for the non-scrolljacking user interface is $M = 3.5$ (SD = 1.192) and $M = 2.3$ (SD = 1.302) for the scrolljacking user interface. The Wilcoxon Signed Rank Test indicates that participants felt significantly more control whilst using the user interface with non-scrolljacking: $W = 36.00$; $z = -2.396$, $p = .017$ with a strong effect size ($r = .535$).

For the question concerning feelings of frustration whilst using the user interfaces, the results are the mean score for the non-scrolljacking user interface is $M = 3.45$ (SD = 1.276) and $M = 4.25$ (SD = 1.164) for the scrolljacking user interface. The Wilcoxon

Signed Rank Test indicates that there is no statistically significant difference between the two scrolling types for feelings of frustration: $W = 36.00$; $z = -1.682$, $p = .093$ with a medium effect size ($r = .376$).

For the question concerning fun factor whilst using the user interfaces, the results are the mean score for the non-scrolljacking user interface is $M = 2.6$ ($SD = .821$) and $M = 2.0$ ($SD = 1.17$) for the scrolljacking user interface. The Wilcoxon Signed Rank Test indicates that there is no statistically significant difference between the two scrolling types for fun factor: $W = 47.00$; $z = -1.730$, $p = .084$ with a medium effect size ($r = .386$).

The questionnaire also asked participants to make a selection regarding which of the two scrolling types they preferred overall. Thirteen participants chose the non-scrolljacking option as their choice. The remaining seven participants expressed their preference for the scrolljacking user interface.

4 Discussion

Based on the data collected and analyzed from the pre-experiment questionnaires, 90% of the participants had never heard of scrolljacking before the experiment.

For performance, the total time to complete the two sets of tasks was monitored, as well as the total number of errors done in each set of tasks. The data analysis showed that the participants made significantly more errors while using the website with scrolljacking. This could be due to the confusion caused by the unexpected change in scrolling behaviour and by the frustration of having to scroll more than needed.

In view of this result, we accept the positive hypothesis at the beginning of this paper, which stated that for errors, there will be a statistically significant difference between the scrolljacking and non-scrolljacking user interfaces.

When it comes to the total time to complete the tasks, the data analysis revealed that the participants were slightly slower (not statistically significant.) in completing their tasks on the website with scrolljacking. This could be due to the fact that a web page using scrolljacking needs to be scrolled completely from top to bottom, as there are no shortcuts available to skip content.

In view of this result, we accept the null hypothesis at the beginning of this paper, which stated that for task execution speed, there will be no statistically significant difference between the scrolljacking and non-scrolljacking user interfaces.

While undergoing the experiment, some of the participants were vocal about their experience using the two prototypes, and even more about their first-hand experience with scrolljacking.

Many of the participants of the experiment described the experience of using the web page with scrolljacking as 'slow', 'infuriating', 'tiring', and 'frustrating to scroll so much'. It was a noticeable pattern that the users in this experiment were used to scrolling big chunks of content at a time, even scrolling from top to bottom in one single motion. One particular scrolljacking functionality led to exactly the opposite of that behaviour, as it blocks the user from proceeding further until all blocks of content are

scrolled. Hence, some of the participants were very frustrated in having to wait to scroll to each part of the page until the bottom.

One comment a participant made during the third task in the second set for the web page with scrolljacking was revealing: 'I would have given up and left the page by now'.

Some of the participants stated that they could see the potential of using scrolljacking in the correct context. They mentioned that they liked how scrolljacking was used for animations, however, it can easily become 'visually weird' if it is overused. Since it could be used for artistic purposes, using it in an online shop where one needs to perform multiple tasks may not represent the best place to use scrolljacking concepts.

During the second set of tasks done on the prototype with scrolljacking, multiple participants tried to scroll the page by grabbing and moving the scrollbar. This capability is not available while using certain kinds of scrolljacking and has been seen as a hindrance by some of the participants, as they were used to the native behaviour of grabbing the scrollbar for scrolling. The fact that the 'Search in Page' browser capability was prohibited during the experiment also represented another hindrance that the participants experienced, as some of them use this capability naturally in their day-to-day tasks.

Multiple users expressed the need to have navigational feedback while they were scrolling on the web page with scrolljacking by mentioning how 'there is no feedback or response from scrolljacking'. Linked to this and aligned to our findings, Ledneva and Kovalev [8] found that a reduction in navigational cues can increase cognitive load.

Many other participants were also looking for navigational components such as 'Go to the top' or 'Go to the bottom', as they were looking for fast ways to jump from one content on the page to another. A web page using scrolljacking does not have these navigational helpers as the implementation forces the user to scroll throughout the entire page. Certain participants appeared to become tired of scrolling more than it was necessary.

In the post-experiment questionnaire, the participants were asked to rate their opinion of four aspects related to the experiment and the use of scrolljacking: ease of use, control, frustration, and fun.

The participants felt the website with scrolljacking to be more difficult for completing their tasks, more frustrating to use and less fun to use. However, the differences are not statistically significant. Further, participants felt that they were a lot less in control whilst using the website with scrolljacking. The differences for feeling of control are statistically significant.

One out four elements on the post-experiment questionnaire is statistically significant (feeling of control). However, taking also into consideration the verbal comments and observations overall, we can accept the positive hypothesis. This stated that in terms of user satisfaction, ratings scores will be statistically significantly different and verbally expressed differences and observations will differ, between the scrolljacking and non-scrolljacking user interfaces. The overall pattern clearly suggests that the non-scrolljacking website was preferred over the scrolljacking version.

In addition, the overall preference question asked in the post-experiment questionnaire shows that 65% of the participants preferred the version of the website without

scrolljacking (i.e. native scrolling functionality). Therefore, only 35% of the participants preferred the scrolljacking interaction.

Furthermore, we find our results link with well established principles. During the experiment, the participants were feeling frustrated, confused, and tired while using the web pages with scrolljacking. These results are against the concepts of good usability for a web page, as seen in multiple web guidelines, e.g. [16, 6]. The Web Content Accessibility Guidelines (WCAG) 2.2 has four main principles and two of their principles can be related directly to scrolljacking: Operable and Understandable. These two principles cover guidelines related to the user interface components and navigation, which have been challenged by using scrolljacking:

- The web pages should behave in a predictable way.
- Provide navigational context and help to navigate.
- The content of web pages should not cause seizures.

Concerning universal design, this can be defined as: ‘the design of products and environments that can be used and experienced by people of all ages and abilities, to the greatest extent possible, without adaptation [15].’ Our experiment has revealed that the users found scrolljacking to be a somewhat tiring and slow user experience. The increased mental effort of using scrolljacking on a web page is directly against the principles of universal design [15], namely the ‘Simple and Intuitive Use’ and the ‘Flexibility in Use’ principles. The principle ‘Simple and Intuitive to Use’ discusses how a design should be easily understood and used by any user, no matter the skill or concentration level. Scrolljacking may violate this principle because our observations suggest that considerably more effort is required on the part of a user when interacting with a web page. The ‘Flexibility in Use’ is about how the user should have multiple options available in using a certain designed artefact. By imposing scrolljacking concepts on a web page, the user may be forced to scroll through the entire content of a web page with no alternative. Furthermore, although this paper is discussing potential issues in relation to all users, the problems observed in our investigation which can be linked with well-known guidelines, can be even greater for individuals with one or more impairments.

5 Concluding Remarks

As mentioned in the Introduction, our main aims with this study were to investigate if scrolljacking had some effect (positive or negative) on usability and universal design.

As seen in the findings of the experiment, the use of scrolljacking in a web page overall has a negative impact on performance and user experience. In addition, implementing scrolljacking is likely to not meet certain WCAG and universal design principles.

Concerning future work linked to shortcomings in this study, we suggest that this could involve a larger study with a larger sample of participants. Furthermore, it would be good to be able to obtain participants with more diverse backgrounds and having one or more impairments. It might also be useful in terms of results to have more

difficult tasks for participants to try in a future study. In addition, sets of tasks that are administered to participants, would ideally be randomized in how they are presented to participants.

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